-hp- 3438A

Address code 23

OPERATING AND SERVICE MANUAL

DIGITAL MULTIMETER

3438A

C 108

Rack Instruments 2

HEWLETT PACKARD

-hp- 3438A

HEWLETT PACKARD

OPERATING AND SERVICE MANUAL

MODEL 3438A

DIGITAL MULTIMETER

Serial Numbers 1717A00330 and Greater

IMPORTANT NOTICE

Any changes made in instruments manufactured after this printing will be found in a "Manual Changes" supplement, supplied with this manual. Be sure to examine this supplement, if one exists for this manual, for any changes which apply to your instrument and record these changes in the manual.

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

Manual Part No. 03438-90002

Microfiche Part No. 03438-90052

P.O. Box 301, Loveland, Colorado 80537 U.S.A.

Printed: May 1979

HEWLETT PACKARD

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [,except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period] . During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HEWLETT-PACKARD SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HEWLETT-PACKARD SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

10/1/79

SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements.

GROUND THE INSTRUMENT.

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

KEEP AWAY FROM LIVE CIRCUITS.

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS.

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

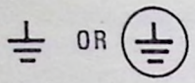
WARNING

Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

General Definitions of Safety Symbols Used On Equipment

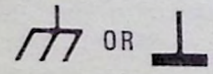
Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



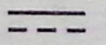
Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



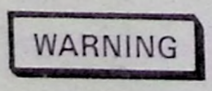
Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

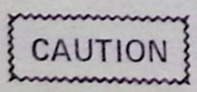


Direct current (power line).

Alternating or direct current (power line).



The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury.



The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information concerning the -hp- Model 3438A Multimeter. Included is an instrument description, specifications, information about instrument and manual identification, option and accessory information, and safety considerations.

1-3. DESCRIPTION.

1-4. The -hp- Model 3438A is an HP—IB compatible, 3½ digit, five function, autoranging multimeter. The functions are AC and DC Voltage, AC and DC Current and Ohms. All five functions have manually selectable ranges. AC and DC Voltage and Ohms functions may also be automatically ranged by depressing the AUTO pushbutton.

1-5. The 3438A enables the user to set up a low cost data gathering system utilizing the HP—IB. Voltage (ac or dc), Current (ac or dc) and resistance information can be transferred on the HP—IB to Printers, Calculators, and Computers for data storage or *hard copy* printouts.

1-6. Throughout the remainder of this manual, the -hp- Model 3438A Multimeter will be referred to as Multimeter.

1-7. SPECIFICATIONS.

1-8. Specifications for the Multimeter are listed in Table 1-1. These specifications are the performance standards or limits to which the Multimeter can be tested. Any changes in these specifications due to manufacturing changes, design or traceability to the National Bureau of Standards will be covered by an errata or change sheet. These specifications supersede any prior published specifications. Supplemental information in Table 1-2 is provided to describe general operating characteristics.

1-9. INSTRUMENT AND MANUAL IDENTIFICATION.

1-10. Hewlett-Packard uses a two-section serial number. The first section (prefix) identifies a series of instruments. The last section (suffix) identifies a particular instrument within the series. A letter between the prefix and the suffix identifies the country in which the instrument was manufactured. The manual is kept up-to-date at all times by means of a change sheet which is supplied with the manual. If the serial number of your instrument differs from the one on the title page of this manual, refer to the change sheet supplied with the manual. All correspondence with Hewlett-Packard should include the complete serial number.

1-11. OPTIONS.

1-12. Table 1-3 lists the options available for the Multimeter.

1-13. The option label affixed to the rear of the Multimeter identifies the line voltage for which the instrument is wired. This operating voltage can be changed by following the procedure outlined in Section V (Power Requirement Modification Instructions). If the line voltage option is changed, the option label should also be corrected to reflect the new configuration.

1-14. ACCESSORIES.

1-15. The accessories available for use with the Multimeter are listed in Table 1-4.

1-16. SAFETY CONSIDERATIONS.

1-17. This Operating and Service Manual contains cautions and warnings alerting the user to hazardous operating and maintenance conditions. This information is flagged by a caution or warning heading and/or the symbol ⚠ . The ⚠ symbol appears on the front panel and is an international symbol meaning "refer to the Operating and Service Manual". This symbol flags important operating instructions located in Section III. To ensure the safety of the operating and maintenance personnel and retain the operating condition of the instrument, these instructions must be adhered to.

Table 1-1. Specifications.

DC VOLTMETER

Ranges	Max Display
± 200 mV	± 199.9 mV
± 2 V	± 1.999 V
± 20 V	± 19.99 V
± 200 V	± 199.9 V
± 1200 V	± 1199 V

Maximum Input: 1200 V (dc + peak ac).

Ranging: Automatic or manual.

Sensitivity: 100 µV on 200 mV range.

Polarity: Automatically sensed and displayed.

Accuracy: 1 Year 15° to 30°C @ 95% RH.

Range	Specifications
200 mV	± (0.1% of reading + 2 digits)
2 V to 1200 V	± (0.1% of reading + 1 digit)

Temperature Coefficient: 0° - 15°C and 30° - 55°C ± (.018% reading + 0.1 digit) /°C

Input Resistance: 10 meg Ω ± 1%.

Input Type: Floating 500 V max COM to ground.

Normal Mode Rejection: 40 dB at 50 Hz and 60 Hz ± .1 Hz.

Effective Common Mode Rejection: With 1 kΩ unbalance is > 120 dB at 50/60 Hz ± 0.1%.

Response Time: < 0.7 seconds to within 1 digit of final value on any range. Add 1 second for each range change.

AC VOLTMETER

AC Converter: Avg. Responding rms calibrated.

Ranges	Max Display
200 mV	199.9 mV
2 V	1.999 V
20 V	19.99 V
200 V	199.9 V
1200 V	1199 V

Maximum Input: 1700 V (dc + peak ac), 10^7 volt - Hz max.

Ranging: Automatic or manual.

Sensitivity: 100 µV on 200 mV range.

Accuracy: 1 year, 15° to 30°C @ 95% RH.

Minimum Reading: 20 digits.

30 Hz - 50 Hz	± (1.5% of reading ± 3 digits)
50 Hz - 20 kHz	± (0.3% of reading ± 3 digits)
20 kHz - 100 kHz	± (1.5% of reading ± 10 digits)

Temperature Coefficient: 0° - 15°C and 30° - 55°C ± (0.04% of reading + 0.2 digits) /°C.

Input Impedance: Resistance: 5 meg Ω.
Shunt Capacitance: < 50 pF.

Input Type: Floating 500 V max COM to ground.

Response Time: 1.6 seconds to within 3 digits of final value on any range. Add 1.2 seconds for each range change.

DC AMMETER

Ranges	Max Display
± 200 µA	± 199.9 µA
± 2 mA	± 1.999 mA
± 20 mA	± 19.99 mA
± 200 mA	± 199.9 mA
± 2000 mA	± 1999 mA

Maximum Input: 2A from < 250 V source.

Protection: 2A/250 V fuse (normal blow).

Ranging: Manual only.

Sensitivity: 100 nA on 200 µA range.

Polarity: Automatically sensed and displayed.

Accuracy: 1 year, 15 to 30°C @ 95% RH.

Range	Specifications
200 µA to 200 mA	± (0.3% of reading + 2 digits)
2000 mA	± (0.6% of reading + 2 digits)

Temperature Coefficient: 0 - 15°C and 30 - 55°C ± (.028% of reading + 0.1 digits) /°C.

Voltage Burden:

Range	Max Burden at Full Scale
200 µA to 20 mA	< 220 mV
200 mA	< 240 mV
2000 mA	< 400 mV

Input Type: Floating 500 V max COM to ground.

Response Time: 0.7 seconds on any range to within 1 digit of final value.

AC AMMETER

Ranges	Max Display
200 µA	199.9 µA
2 mA	1.999 mA
20 mA	19.99 mA
200 mA	199.9 mA
2000 mA	1999 mA

Maximum Input: 2A from < 250 V source.

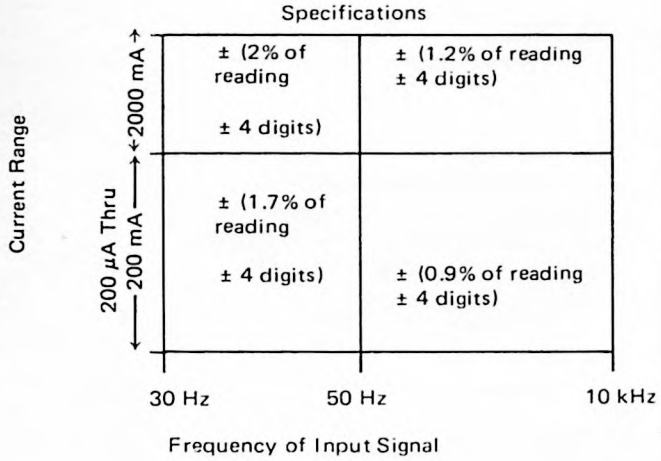
Protection: 2A/250 V fuse (normal blow).

Ranging: Manual only.

Sensitivity: 100 nA on 200 µA range.

Accuracy: With display of ⩾ 20 digits.
1 year 15 to 30°C 95% RH.

Table 1-1. Specifications (Cont'd).



Temperature Coefficient: 0 - 15°C and 30 - 55°C ± (0.05% of reading + 0.2 digits) /°C.

Voltage Burden:

200 µA to 20 mA	< 220 mV rms
200 mA range	< 240 mV rms
2000 mA range	< 400 mV rms

Input Type: Floating 500 V max COM to ground.

Response Time: 1.6 seconds on any range to within 3 digits of final value.

OHMMETER

Ranges	Max Display
20 Ω	19.99 Ω
200 Ω	199.9 Ω
2 kΩ	1.999 kΩ
20 kΩ	19.99 kΩ
200 kΩ	199.9 kΩ
2000 kΩ	1999 kΩ
20 MΩ	19.99MΩ

Input Protection: 250 V rms.

Ranging: Automatic, or manual.

Sensitivity: 10 milliohm on 20 Ω range.

Accuracy: 1 year 15 to 30°C at 95% RH.

Range	Specification
20 Ω	± (0.5% of reading + 10 digits)
200 Ω to 2 MΩ	± (0.2% of reading + 2 digits)
20 MΩ	± (0.8% of reading + 2 digits)

Temperature Coefficient: 0 - 15°C and 30 - 55°C.

Range	Specifications
20 Ω to 2MΩ	± (0.04% of reading + 0.2 digits) /°C
20 MΩ	± (.18% of reading + 0.2 digits) /°C

Configuration: 2 wire.

Open Circuit Voltage: < 5 V max.

Current through unknown:

Range	20Ω	200Ω	2kΩ	20kΩ	200kΩ	2MΩ	20MΩ
Current	5mA	5mA	500µA	50µA	5µA	500nA	50nA

Response Time: 0.8 seconds to within 1 digit of final value. Add 0.8 seconds for each range change.

In accordance with IEEE–488–1975, the 3438A Multimeter meets the following Interface Function Specifications.

Interface Function	Description	3438A Capability
SH1	Source handshake	Yes
AH1	Acceptor handshake	Yes
T7	Talker (basic talker, talk only mode, unaddress-to-talk if addressed-to-listen	Yes
L4	Listener (basic listener, unaddress-to-listen if addressed-to-talk)	Yes
E1	Open collector Bus driver	Yes
DT1	Device trigger	Yes
RL2	Remote/Local	Yes
LL0	Local lock-out	No
SRQ	Service Request	No
PP0	Parallel poll	No
DC0	Device clear	No
C0	Controller	No

Table 1-2. General Information.

GENERAL:

Display: 7 segment RED 0.3 inch high LED's. Function and range annunciation.

Reading rate: 2.4 - 4.7/sec. depending on input level.

A-D Conversion: Dual slope.

Integration time: 100 msec.

Ranging: Automatic or manual in ac V, dc V and ohms. Manual only in ac and dc current.

Storage Temperature: (-40 to +75)°C;

Operating Temperature: (0 to 55)°C.

Humidity: 0 - 95% RH at 40°C.

Power: AC line; 48 - 440 Hz
86-106 V Opt. 100
104-127 V Opt. 115
190-233 V Opt. 210
208-250 V Opt. 230

Total Instrument Power Dissipated: 12 watts

Configuration: 3438A Std, Rack and Stack case, ac line power only. Rack mount kit not included.

Dimensions: 20.96 cm (8 1/4") wide x 8.57 cm (3 3/8") high x 31.12 cm (12 1/4 in.)

Weight: 2.87 kg (6 lbs. 5 oz.)

Table 1-3. Options.

Standard	Rack mount case. AC line operation only.		
Option 100	86 - 106 Vac	48 - 440 Hz	12 Watts
Option 115	104 - 127 Vac	48 - 440 Hz	12 Watts
Option 210	190 - 233 Vac	48 - 440 Hz	12 Watts
Option 230	208 - 250 Vac	48 - 440 Hz	12 Watts
Option 908	Rack Mount Kit . -hp- Part Number 5061-0054.		
Option 910	An additional Operating and Service Manual.		

Table 1-4. Accessories.

11002A	Test leads (dual banana to dual alligator).
11003A	Test leads dual banana to probe and alligator.
11096B	RF Probe 10 kHz to 700 MHz, use only 10 V and 100 V dc ranges.
5061-0054	Rack adapter kit including ½ module filler panel.
34110A	Soft vinyl carrying/operating case.
34111A	High voltage probe, 40 kV dc
34112A	Touch - Hold, input probe.
11067A	Test lead kit.
11000 A	Test leads, dual banana on both ends
10631A	1M (39.37") HP–IB Cables
10631B	2M (78.74") HP–IB Cables
10631C	4M (157.48") HP–IB Cables

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions for the installation and shipping of the Multimeter. Included are initial inspection procedures, power and grounding requirements, environmental information, and instructions for repackaging the instrument for shipment.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage in transit. Electrical performance should be tested using the performance test outlined in Section V. If there is damage or deficiency, see the warranty inside the front of this manual.

2-5. POWER REQUIREMENTS.

2-6. The Multimeter can be operated from any one of the ac power sources listed in Table 1-2. Before connecting the instrument to ac power, verify that the ac power source matches the power requirement of the instrument as marked on the option label affixed to the rear of the instrument. If the instrument is incompatible with the available power source, refer to Section V for Power Requirement Modification instructions.

2-7. ENVIRONMENTAL REQUIREMENTS.

2-8. The Multimeter will meet the specifications listed in Table 1-1 when the operating temperature is within the range of + 15°C to + 30°C. The instrument can be operated where the ambient temperature is within the range of 0°C to + 40°C and the relative humidity is less than 95%.

WARNING

To prevent potential electrical or fire hazard, do not expose equipment to rain or moisture.

2-9. INSTRUMENT MOUNTING.

2-10. The Multimeter is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument. The front of the instrument may be elevated for convenience of operating and viewing by extending the tilt stand. The plastic feet are shaped to permit placing the instrument on top of other System II half or full module Hewlett-Packard instruments.

2-11. HEWLETT—PACKARD INTERFACE BUS (HP—IB).

2-12. Figure 2-1 illustrates the rear panel HP—IB connector, along with a brief description of each signal line.

2-13. Interface Cable Length.

2-14. The maximum accumulative length of an HP—IB cable in any system must not exceed more than 2 meters of cable per device (up to 15 devices) or 20 meters, whichever is less.

2-15. REPACKAGING FOR SHIPMENT.

2-16. The following paragraphs contain a general guide for repackaging the instrument for shipment. Refer to Paragraph 2-17 if the original container is to be used, 2-18 if it is not. If you have any questions, contact your nearest -hp- Sales and Service Office. (See Appendix A for office locations.)

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number.

2-17. Place instrument in original container with appropriate packing material and seal well with strong tape or metal bands. If original container is not available, one can be purchased from your nearest -hp- Sales and Service Office.

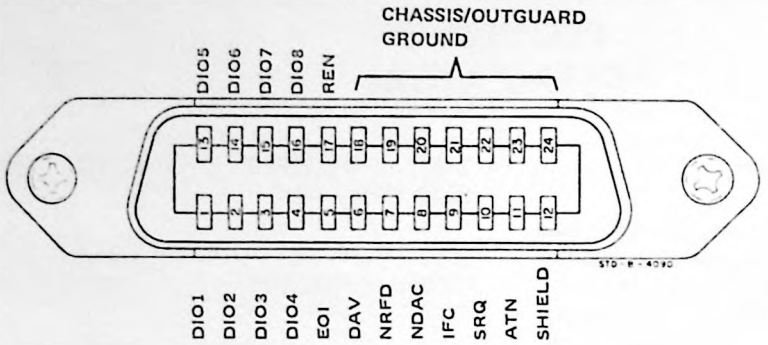
2-18. If original container is not to be used, proceed as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of instrument and protect front panel with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal well with strong tape or metal bands.

HP-IB CONNECTOR J701



Mating Connector:

-hp- Part No. 1251-0293
Amphenol No. 57—30240

Mating Cables:

10631A 3 ft.
10631B 6 ft.
10631C 12 ft.

DIO 1-8 (Data Input/Output)
Mnemonic referring to the eight "Data Input/Output" lines. The DIO lines transfer messages in a byte-serial, bit parallel manner.

EOI (End or Identify)
Mnemonic referring to the "End or Identify" control line. EOI is used by a device to indicate the end of a multiple-byte transfer.

DAV (Data Valid)
Mnemonic referring to the "Data Valid" control line. DAV is used to coordinate the "handshake" sequence. The DAV line is controlled by the source (talker). When DAV is true, data on the DIO lines is considered valid.

NRFD (Not Ready For Data)
Mnemonic referring to the "Ready For Data" control line. NRFD is used to coordinate the "handshake" sequence. The NRFD line is controlled by the acceptor (listener). When NRFD is true, the acceptor indicates to the source that he is ready to accept data.

NDAC (Data Not Accepted)
Mnemonic referring to the "Data Accepted" control line. NDAC is used to coordinate the "handshake" sequence. The NDAC line is controlled by the acceptor (listener). When NDAC is true, the acceptor indicates to the source that the data on the DIO lines has been accepted.

IFC (Interface Clear)
Mnemonic referring to the "Interface Clear" control line. IFC is used to place the HP-IB system in a known quiescent state. The IFC line is controlled by the system controller.

SRQ (Service Request) *Not Available in 3438A*
Mnemonic referring to the "Service Request" control line. SRQ is used (by any device having service request capability) to indicate to the system controller that the device requires service. The controller responds by polling the devices to determine which device requested service.

ATN (Attention)
Mnemonic referring to the "Attention" control line. The state of the ATN line determines whether the HP-IB is in the "Command mode" (ATN true) or the "Data mode" (ATN false). When ATN is true, all devices must listen to the data lines, and when ATN is false, only devices that have been addressed will actively transfer data.

REN (Remote Enable)
Mnemonic referring to the "Remote Enable" control line. REN is used in conjunction with listen addresses (DIO 1-8) to select either local or remote control of each device.

For further information concerning the HP-IB, refer to "Hewlett-Packard Interface, A Compendium of Technical Articles" -hp- publications No. 5952-2472.

Figure 2-1. Hewlett-Packard Interface Bus Connector.

2-19. POWER CORDS AND RECEPTACLES.

2-20. Figure 2-2 illustrates the plug cap configurations that are available to provide ac power to the Multimeter. The -hp- part number shown directly below each plug cap drawing is the part number for the power cord set equipped with the appropriate mating plug for that receptacle. The appropriate power cord should be provided with each instrument. However, if a different power cord set is required, notify the nearest -hp- Sales and Service Office and a replacement cord will be provided. The instrument ac power input receptacle and cord set appliance coupler meet the safety specifications set by the International Commission on Rules for the Approval of Electrical Equipment (CEE 22).

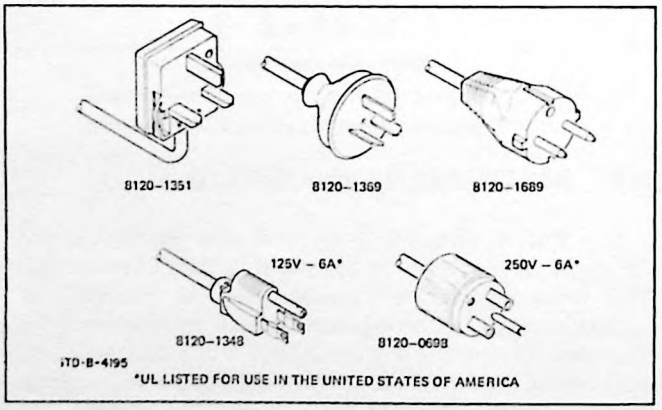


Figure 2-2. Power Receptacles.

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains instructions for operating the Multimeter. Measurements of ac and dc voltage, ac and dc current, and ohms are discussed. Sample applications will be given in this section to demonstrate the use of the HP-IB. A description of the controls and connectors is given in Figure 3-3.

WARNING

To prevent potential electrical or fire hazard, do not expose the Multimeter or its accessories to rain or moisture.

3-3. AC Operation.

3-4. Before connecting the Multimeter to ac power, verify that the ac power source matches the power requirements of the Multimeter as marked on the option label affixed to the rear of the instrument. If the instrument is incompatible with the available power source, refer to Section V of this manual for power requirement modification instruction. After this verification, connect the proper ac power to the instrument and press the ON button. The instrument is ready for use.

3-5. Overload/Overrange/Improper Function Indication.

3-6. Figure 3-1 shows the display indication during overload, overrange, or an improper switch setting.

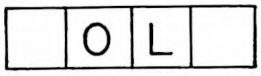


Figure 3-1. Overload Indication.

3-7. Table 3-1 lists improper switch combinations.

Table 3-1. Improper Switch Combinations.

Function	Range		
⎓ V		MΩ 20	
~ V	mV, Ω 20	MΩ 20	
⎓ mA	mV, Ω 20	MΩ 20	Auto
~ mA	mV, Ω 20	MΩ 20	Auto

3-8. Auto.

3-9. Depressing the AUTO switch with acV, dcV or kΩ function selected sets the Multimeter in an automatic ranging mode. In this mode the Multimeter will *uprange* if the display increases above (+) or (-) 1999 and *downrange* if the display decreases below (+) or (-) 180. These numerical autoranging points are irrespective of decimal placement. The difference between the two autoranging points is called *autoranging Hysteresis.* Figure 3-2 shows the autoranging points for dc voltage measurements from 0 to 1200 V dc. Autoranging in other Multimeter functions is similar.

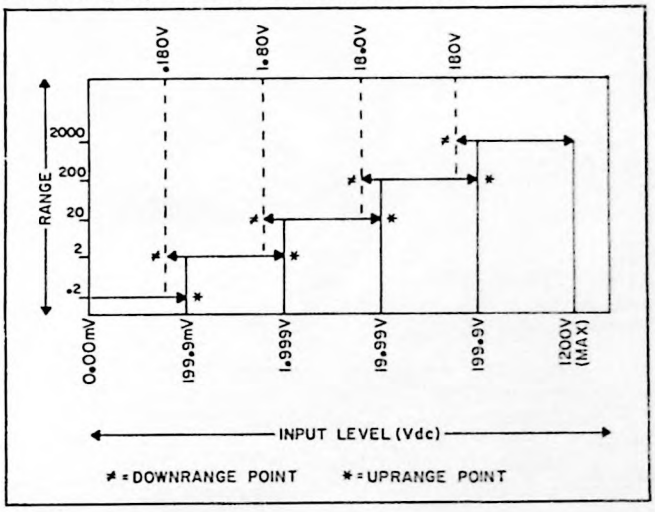


Figure 3-2. Multimeter Autoranging.

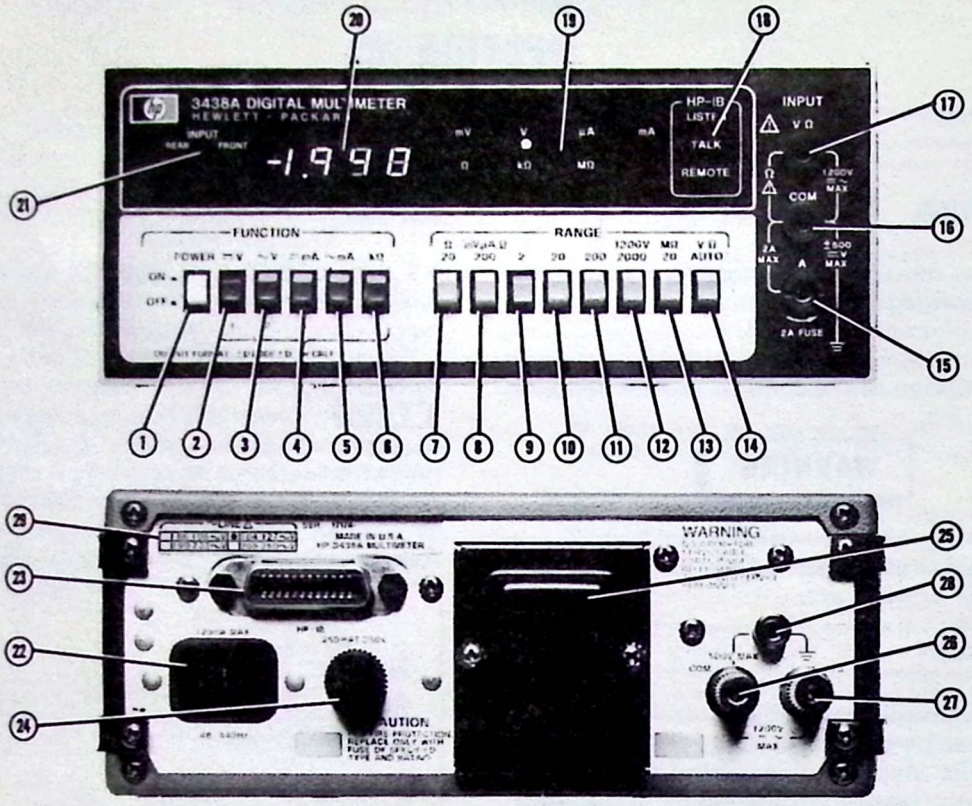
3-10. To release the AUTO switch depress one of the MANUAL RANGE switches.

3-11. Input Terminals.

3-12. Input Selector Switch. The Input Selector Switch (front panel) is used to select front or rear input terminals. In the FRONT poisiton, the VΩ, COM and A input terminals are internally connected to enable the user to make voltage, current, and resistance measurements from the front panel. With the Input Selector switch set to REAR, the VΩ and COM input terminals on the rear panel are connected to allow the user to make voltage and resistance measurements.

NOTE

There is no current measuring capability from the rear input terminals.



DESCRIPTION

(1) POWER ON/OFF SWITCH. SWITCHES MULTIMETER POWER ON OR OFF.

FUNCTION SWITCHES: USED TO SELECT THE FIVE MULTIMETER FUNCTIONS.

(2) DC VOLTAGE FUNCTION SWITCH.

(3) AC VOLTAGE FUNCTION SWITCH.

(4) DC MILLIAMPERES FUNCTION SWITCH.

(5) AC MILLIAMPERES FUNCTION SWITCH.

(6) KILOHMS FUNCTION SWITCH.

MANUAL RANGE SWITCHES: USED TO SELECT INPUT MEASUREMENT RANGES.

(7) 20 OHMS RANGE SWITCH (OHMS ONLY).

(8) 200 MILLIVOLT, MICROAMP AND OHMS RANGE SWITCH.

(9) 2 VOLT, MILLIAMP AND KILOHM RANGE SWITCH.

(10) 20 VOLT, MILLIAMP AND KILOHM RANGE SWITCH.

(11) 200 VOLT, MILLIAMP AND KILOHM RANGE SWITCH.

(12) 1200 VOLT, 2000 MILLIAMP AND KILOHM RANGE SWITCH.

(13) 20 MEGOHM RANGE SWITCH (OHMS ONLY).

(14) AUTO RANGE SWITCH. AUTOMATICALLY SELECTS RANGE FOR BEST RESOLUTION WHEN AC VOLTS, DC VOLTS, OR OHMS FUNCTIONS ARE SELECTED.

INPUT TERMINALS.

(15) AMPS INPUT TERMINAL: USED IN CONJUNCTION WITH THE COM TERMINAL FOR MEASURING AC AND DC CURRENT. ALSO USED FOR READING HOLD INPUT.

(16) COM INPUT TERMINAL: COMMON TERMINAL FOR AC/DC VOLTS, AC/DC AMPS AND OHMS MEASUREMENTS.

(17) VOLTS/OHMS INPUT TERMINAL: USED IN CONJUNCTION WITH THE COM TERMINAL FOR MEASURING AC/DC VOLTAGE AND OHMS.

(18) HP—IB STATUS ANNUNCIATORS.

(19) FUNCTION/RANGE ANNUNCIATORS.

(20) DISPLAY: FOUR SECTION LED READOUT. LEFT SECTION DISPLAYS +/- 1. RIGHT THREE SECTIONS ARE 7 SEGMENT.

(21) INPUT SELECTOR SWITCH: IN THE REAR POSITION, THE VΩ AND COM INPUTS ARE SWITCHED TO THE REAR PANEL AND THE FRONT PANEL INPUT TERMINALS ARE OPEN. IN THE FRONT POSITION, THE REAR PANEL INPUT TERMINALS ARE OPEN. REAR TERMINALS CANNOT BE USED FOR CURRENT MEASUREMENTS.

(22) AC POWER RECEPTACLE.

(23) HP—IB CONNECTOR.

(24) AC POWER INPUT FUSE.

(25) POWER SUPPLY TRANSFORMER.

(26) COM INPUT TERMINAL. SAME AS (16) EXCEPT NO CURRENT MEASUREMENTS WHEN USING REAR TERMINALS.

(27) VΩ INPUT TERMINAL. SAME AS (17) WHEN USING REAR TERMINALS.

(28) POWER LINE GROUND TERMINAL.

(29) SERIAL NUMBER, LINE VOLTAGE LABEL.

Figure 3-3. Front and Rear Panel Descriptions.

CAUTION

To avoid possible damage to the Multimeter, do not change the position of the Input Selector switch while voltage is connected to the front or rear input terminals.

3-13. VΩ (Volts/Ohms). The VΩ terminal (front or rear panel) is the *high* terminal for ac and dc voltage measurements. For ohms measurements, it is the positive (+) terminal.

3-14. COM (Common). The COM terminal is used for all five Multimeter functions. It is the negative (-) terminal for ohms measurements and it is the *low* terminal for ac and dc voltage and current measurements. The rear panel COM terminal is only used for voltage and resistance measurements.

⚠ CAUTION

To avoid possible damage to the Multimeter circuitry, the voltage between COM and (earth ground) must not exceed plus or minus 500 V dc.

3-15. A (Amps). The A terminal is the *high* terminal for ac and dc amps measurements. There is a 2 amp input protection fuse in series with this terminal.

⚠ CAUTION

The current function is protected by a fuse of 250 V rating. To avoid damage to the Multimeter, current sources having open circuit voltages greater than 250 V (dc + peak ac) must not be connected to the A (amps) input terminal.

3-16. DC Voltage Measurements (Front or Rear Input Terminals).

⚠ CAUTION

To avoid possible damage to the Multimeter circuitry, the dc input voltage must not exceed 1200 V (dc + peak ac).

3-17. Procedure.

a. Depress ⎓ V (dc volts).

b. Depress proper manual range (200 mV to 1200 V) or depress AUTO for automatic range selection.

c. Connect test leads from the Multimeter VΩ (high) and COM (low) terminals to the voltage under test as shown in Figure 3-4.

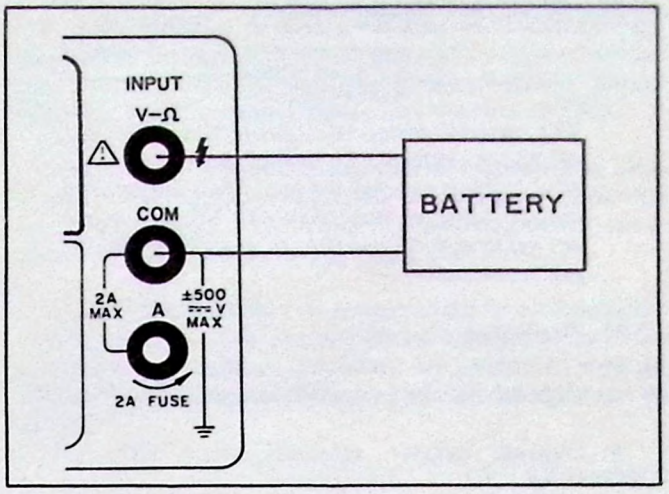


Figure 3-4. DC Voltage Measurements.

3-18. AC Voltage Measurements (Front or Rear Input Terminals).

⚠ CAUTION

To avoid possible damage to the Multimeter circuitry, the ac input voltage must not exceed 1700 V (dc + peak ac).

3-19. Procedure.

a. Depress ~ V (ac volts).

b. Depress proper manual range (200 mV to 1200 V) or depress AUTO for automatic range selection.

c. Connect test leads from the Multimeter VΩ (high) and COM (low) terminals to the voltage under test as shown in Figure 3-5.

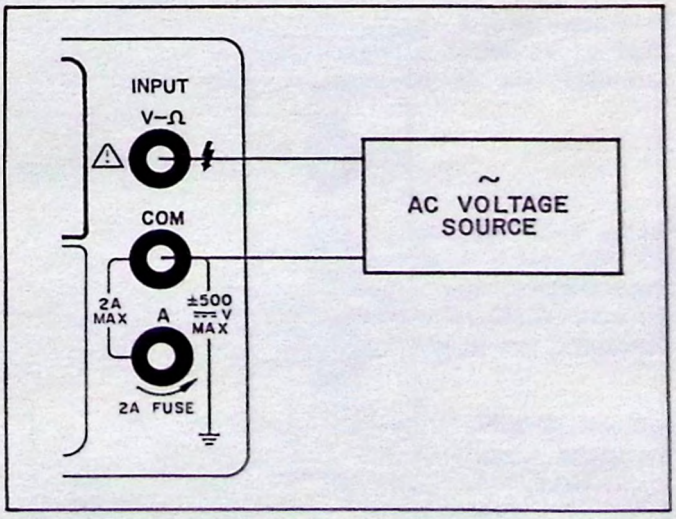


Figure 3-5. AC Voltage Measurement.

3-20. DC Current Measurements.

⚠ CAUTION

The current function is protected by a fuse of 250 V rating. To avoid damage to the Multimeter, current sources having open circuit voltages greater than 250 V (dc + peak ac) must not be connect to the A (amps) input terminal.

3-21. Procedure.

a. Depress ⎓ mA (dc milliamperes).

b. Depress proper manual range (200 μA to 2000 mA).

c. Connect test leads from the Multimeter A and COM terminals in series with the current under test as shown in Figure 3-6.

3-22. AC Current Measurements.

⚠ CAUTION

The current function is protected by a fuse of 250 V rating. To avoid damage to the Multimeter, current sources having open circuit voltages greater than 250 V (dc + peak ac) must not be connected to the A (amps) input terminal.

3-23. Procedure:

a. Depress ~ mA (ac milliamperes).

b. Depress proper manual range (200 μ to 2000 mA).

c. Connect test leads from the Multimeter A and COM terminals in series with the current under test as shown in Figure 3-7.

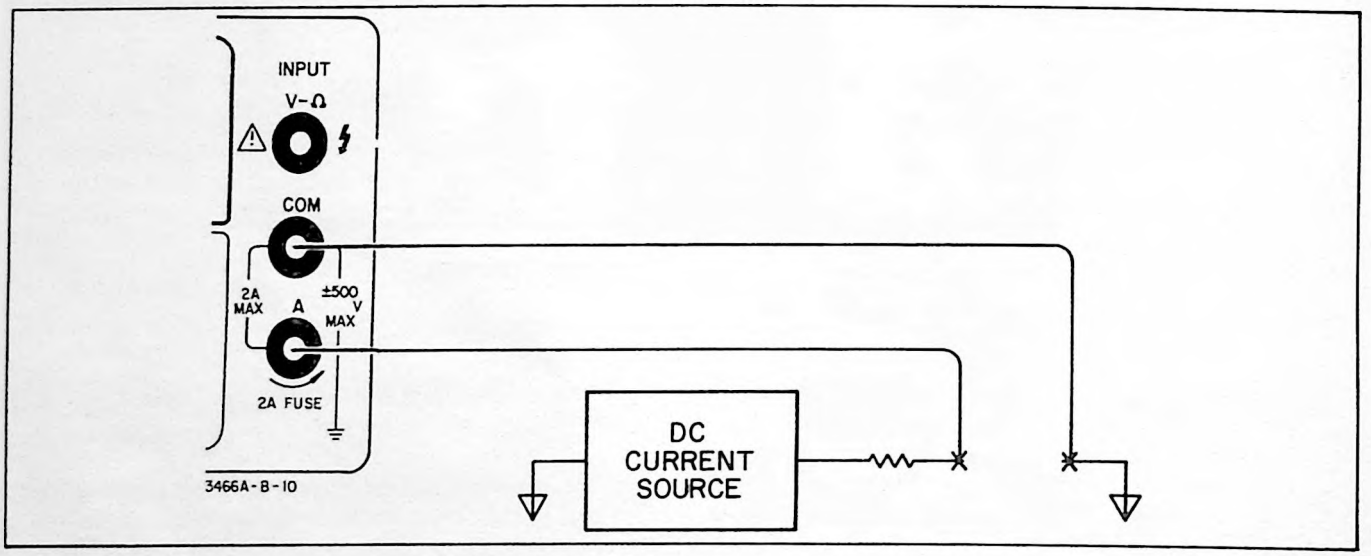


Figure 3-6. DC Current Measurements.

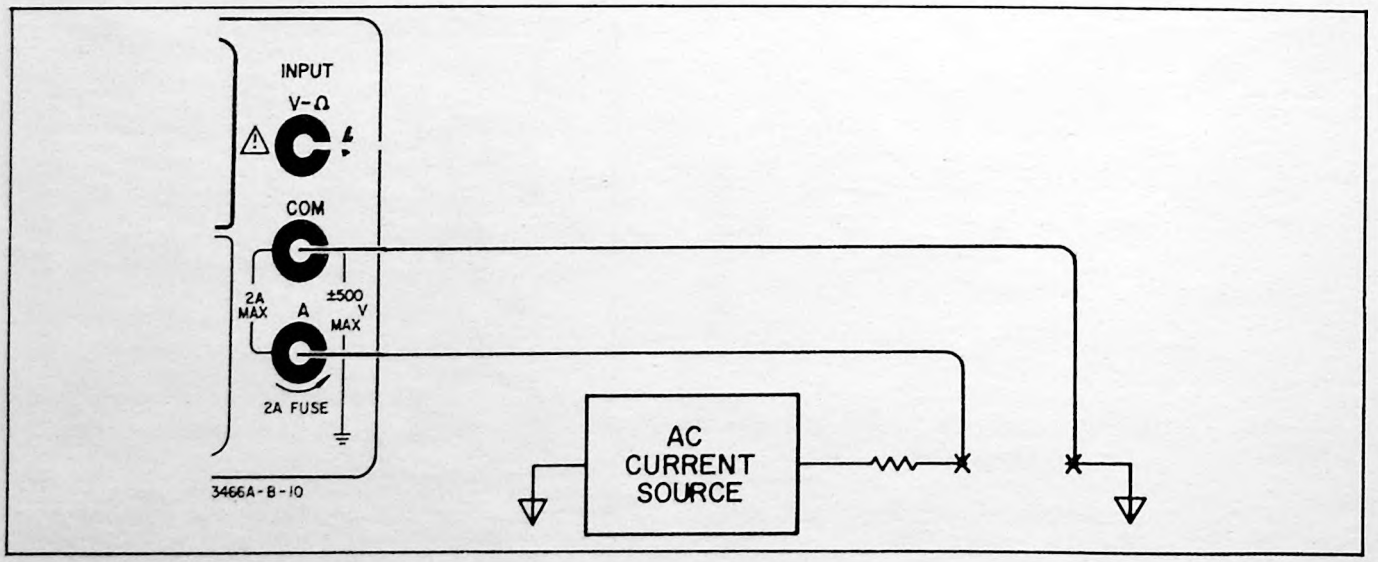


Figure 3-7. AC Current Measurements.

3-24. Resistance Measurements (Front or Rear Input Terminals).

3-25. Procedure.

a. Depress kΩ (kilohms).

b. Depress proper manual range or Auto for automatic range selection (20 Ω to 20 MΩ).

c. Connect test leads from the Multimeter VΩ (=) and COM (-) terminals to the resistance under test as shown in Figure 3-8.

NOTE

When making resistance measurements using the lower ohms ranges, consideration should be given to the resistance of the test leads. This potential measurement error can be eliminated by measuring the lead resistance and subtracting it from the combined resistance value of the test leads and the resistance under test.

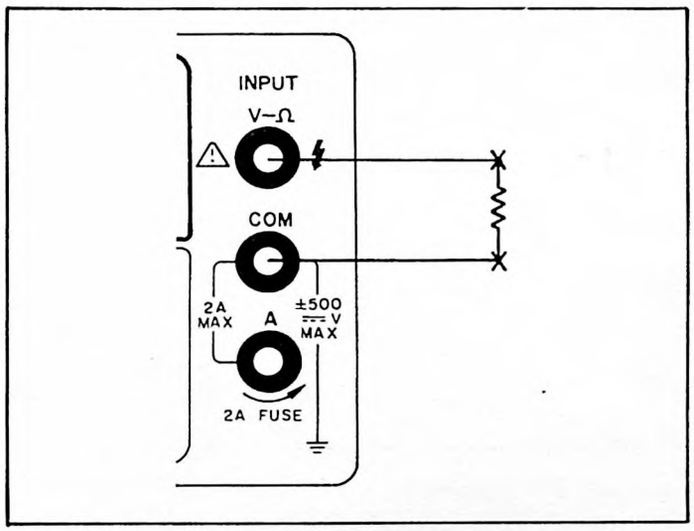


Figure 3-8. Resistance Measurement.

3-26. HP-IB OPERATION.

3-27. The Hewlett-Packard Interface Bus (HP-IB) is Hewlett-Packard's implementation of IEEE Standard 488-1975, "Standard Digital Interface for Programmable Instrumentation."

3-28. BUS STRUCTURE.

3-29. Communication between devices on the HP-IB employs the three basic functional elements listed below. Every device on the Bus must be able to perform at least one of these functions:

a. LISTENER - A device capable of receiving data from other instruments. Examples of this type of device are: printers, display devices, programmable power supplies, programmable signal sources and the like.

b. TALKER - A device capable of transmitting data to other instruments. Examples of this type of device are: tape readers, voltmeters that are outputting data, counters that are outputting data, and so on.

c. CONTROLLER - A device capable of managing communications over the HP-IB such as addressing and sending commands. A calculator or computer with an appropriate I/O interface is an example of this type of device.

3-30. The HP-IB consists of sixteen signal lines, whose functions can be separated into three categories:

a. DATA LINES - Eight bi-directional DATA lines are used to carry instrument addresses, control instructions, and measurement results in a bit-parallel, byte-serial form. A seven-bit ASCII code represents each byte of DATA, with an eighth bit available for parity checking.

b. HANDSHAKE LINES - Three lines are used to transfer data between devices using an interlocked "handshake" technique. The purpose of the HANDSHAKE lines is to coordinate the asynchronous transfer of data.

c. CONTROL LINES - The remaining five lines operate independently and in conjunction to send Bus Management Messages to the devices connected to the HP-IB. The HP-IB interface connections and bus structure are shown in Figure 3-9.

3-31. The 3438A has two usable HP-IB modes of operation, namely, Talk Only and Addressed To Talk. Both modes will be discussed in the following paragraphs.

3-32. Talk Only Mode.

3-33. The Talk Only Mode is used in an HP-IB system without a controller. The Address Switches AS6 and AS7, which are located on the A3 Logic board (remove top cover), must be set as shown in Figure 3-10 for this mode. AS1 through AS5 may be set in any position.

3-34. In the Talk Only mode with no other devices connected to the Multimeter, the Multimeter inputs are sampled continuously at a rate of 2.4 - 4.7/sec determined by the exact input level. Data is output at the HP-IB terminal *as fast* as it is obtained. Refer to Table 3-2.

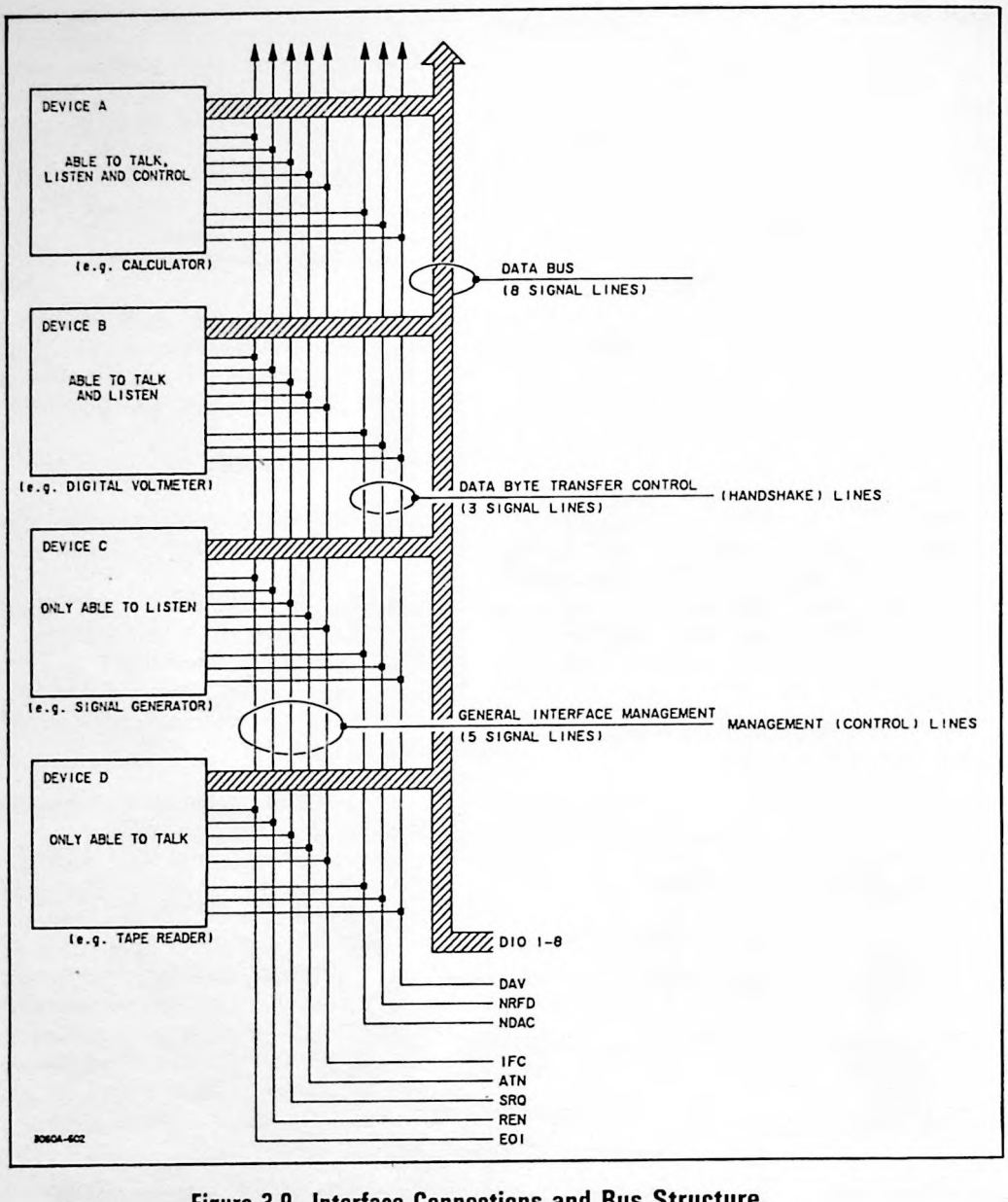


Figure 3-9. Interface Connections and Bus Structure.

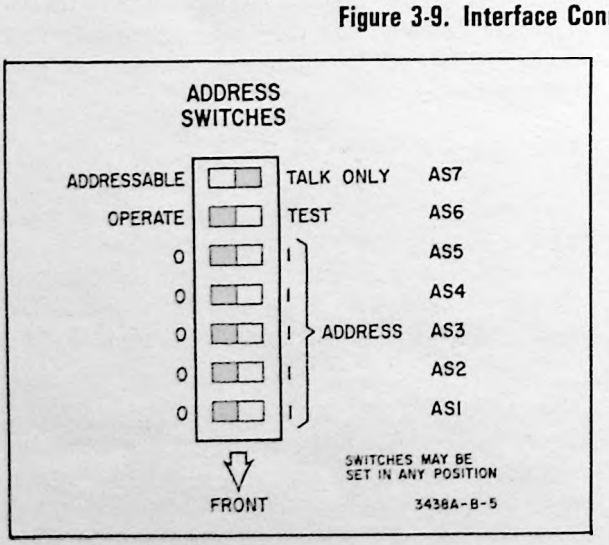


Figure 3-10. Talk Only Switch Settings.

Table 3-2. Output Delays.

Bus Commands	Time Required
Group Execute Trigger (GET)	⩽ 1 msec
Dual Slope Conversion	⩽ 300 msec
Multimeter Output Availability	⩽ 9 msec
GET thru Output Availability*	⩽ 310 ms
Time to Output Data to the HP–IB	⩽ 900 μs + Listener delay
Time to Accept Data from the HP–IB	310 μs/character; 100 μs/character typical

*After 100 ms Auto Zero

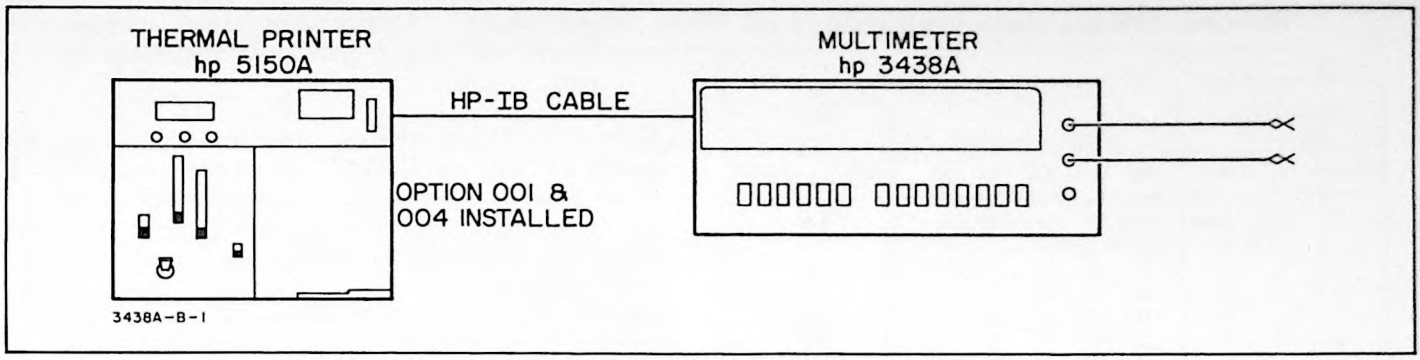


Figure 3-11. Talk Only Data Logger.

3-35. With other devices connected to the Multimeter via the HP-IB, the output data rate is determined by the slowest Listener. The following application shows a simple data logging system using the -hp- Model 3438A Multimeter and the -hp- Model 5150A Thermal Printer.

3-36. Procedure:

a. With both instruments OFF, connect the HP-IB cable between them.

b. Set Printer to LISTENING (back panel).

c. Set Printer PRINT COMMAND switch to LF (line feed).

d. Set the Printer front panel to the desired Print Interval.

NOTE

If the selected print interval is less than the Multimeter output rate, the actual print **interval** *will be equal to the Multimeter sample period.*

e. Set the PRINT TIME switch to Sep Line (separate line).

f. Set the Multimeter Address Switch to Talk Only/Operate as shown in Figure 3-10.

g. Select the desired Multimeter Function and Range and connect the Multimeter to the unknown voltage, current, or resistance.

h. Switch both instruments ON and set the printer clock time (front panel). The Multimeter TALK annunciator light should be ON.

3-37. This system (see Figure 3-11) will print the Multimeter data and the Printer clock time. Any HP-IB compatible LISTENER can be used in place of the -hp- Model 5150A Printer for this system.

3-38. If Option 003 is installed in the 5150A Printer, as many as thirteen 3438A Multimeters can be scanned on one HP-IB data logger system.

3-39. Addressed To Talk Mode.

3-40. The controller must send commands to specific instruments in order to direct information transfer. Each HP-IB device has a unique "address," which is used by the controller to specify that particular device. This address is user-selectable in the 3438A by the internal address switches AS1 through AS5. The Multimeter is shipped with address select code 23 as shown in Figure 3-12. This switch is binary coded.

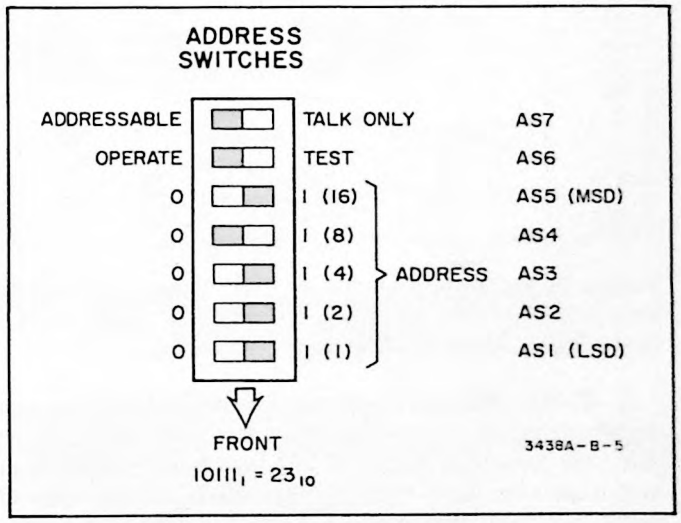


Figure 3-12. Address Select Code.

3-41. When a device, such as the 3438A, is both a talker and a listener, it has separate addresses for each mode. The talk and listen addresses are assigned in pairs, and depend on the 5-bit address code which has been selected by switches AS1 through AS5. Referring to Table 3-3, if the 5-bit address code is set to 23_{10} (10111_2), the corresponding listen address is the ASCII character "7," while the talk address is the ASCII character "W".

3-42. Bus Commands.

3-43. The HP-IB operates in one of two modes, the "Command Mode" or the "Data Mode." The state of the ATN (attention) line, determined by the controller, defines how data on the eight DIO (data) lines is inter-

Table 3-3. Talk and Listen Address.

ASCII Code Character		Address Switches					5-bit Decimal Code
Listen	Talk	A5	A4	A3	A2	A1	
SP	@	0	0	0	0	0	00
!	A	0	0	0	0	1	01
"	B	0	0	0	1	0	02
#	C	0	0	0	1	1	03
$	D	0	0	1	0	0	04
%	E	0	0	1	0	1	05
&	F	0	0	1	1	0	06
'	G	0	0	1	1	1	07
(	H	0	1	0	0	0	08
)	I	0	1	0	0	1	09
*	J	0	1	0	1	0	10
+	K	0	1	0	1	1	11
,	L	0	1	1	0	0	12
-	M	0	1	1	0	1	13
.	N	0	1	1	1	0	14
/	O	0	1	1	1	1	15
0	P	1	0	0	0	0	16
1	Q	1	0	0	0	1	17
2	R	1	0	0	1	0	18
3	S	1	0	0	1	1	19
4	T	1	0	1	0	0	20
5	U	1	0	1	0	1	21
6	V	1	0	1	1	0	22
7	W	1	0	1	1	1	23
8	X	1	1	0	0	0	24
9	Y	1	1	0	0	1	25
:	Z	1	1	0	1	0	26
;	[	1	1	0	1	1	27
<	\	1	1	1	0	0	28
=	]	1	1	1	0	1	29
>	~	1	1	1	1	0	30

preted by other devices on the bus. When ATN is low (true), the HP-IB is in Command Mode; when ATN is high (false), the HP-IB is in the Data Mode.

a. *Talker Address* - only one bus device at a time may act as the talker. When the controller addresses a unit to talk, the previous talker is automatically unaddressed and ceases to be a talker. Confusion would result if more than one device were allowed to talk at a time.

b. *Listener Address* - up to 14 devices at a time may be listeners.

c. *Universal Commands* - bus devices capable of responding to those commands will do so at any time regardless of whether they are addressed.

d. *Addressed Commands* - these commands are similar to universal commands except that they are recognized only by devices that are addressed as listeners.

e. *Unaddress Commands* -

1. "Unlisten" Address Command - unaddresses all listeners previously addressed to listen.

2. "Untalk" Address Command - unaddresses all talkers previously addressed to talk.

3-45. In "Command Mode," one or more special codes known as "bus commands" are placed on the HP-IB. These commands have the same meaning in all bus systems. Each device is designed to respond to those commands which have a useful meaning to the device and will ignore all others. The operating manual will state which commands the device will obey. Bus commands fall into three categories:

(a) *Universal* commands affect all devices on the bus, whether addressed or not.

(b) *Addressed commands* affect only those devices which are addressed to listen.

(c) *Unaddress commands* are obeyed by all addressable devices. These commands unaddress devices that are currently addressed.

Bus commands to which the 3438A will respond are listed in Table 3-4.

3-46. Control Lines.

3-47. Of the five control lines, the 3438A is designed to respond to only three:

a. ATN - when ATN is low (true), the HP-IB is in Command Mode; when ATN is high (false), the HP-IB is in the Data Mode.

b. IFC - (Interface Clear). Only the system controller can activate this line. Setting IFC true causes all talkers and listeners to go to their inactive states.

c. REN - (Remote Enable). The system controller sets REN low and then addresses the devices to Listen before they will operate under remote control.

3-48. Handshake Lines.

3-49. The handshake lines are shown in Figure 3-9. The mnemonics of each line have the following meaning:

DAV - Data Valid
NRFD - Not Ready For Data
NDAC - Not Data Accepted

The handshake timing sequence is illustrated in Figure 3-13. Each data byte transferred by the interface system uses the handshake process when exchanging data between source and acceptor. In Data Mode, the source is a Talker and the acceptor is a Listener.

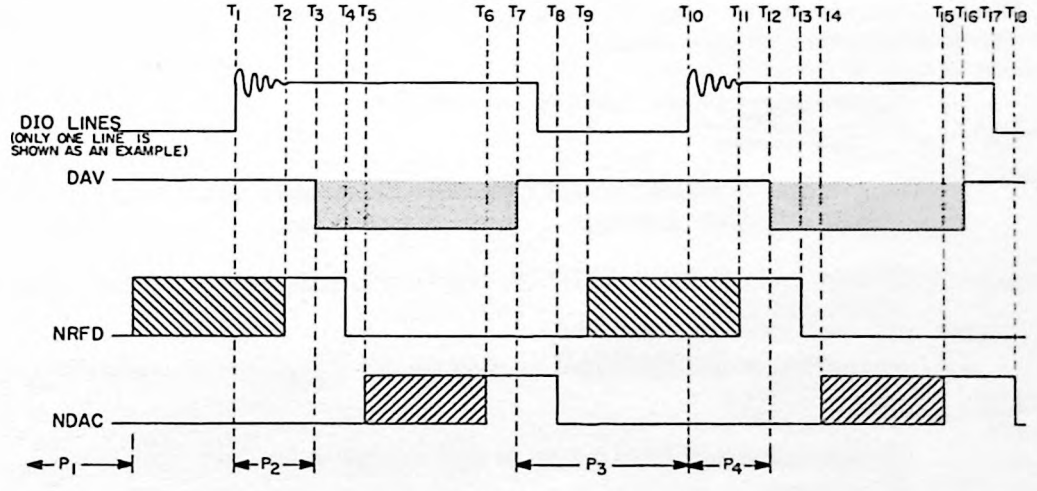
Table 3-4. 3438A Bus Commands.

	Command	ASCII Character	Octal Code	Purpose
Unaddress Commands	UNL Unlisten UNT Untalk	? ---	077 137	Clears Bus of all listeners Unaddresses current talker so that no talker remains on the Bus*
Universal Commands	None	None	None	None
Addressed Commands	GTL Go to Local GET Group Execute Trigger	SOH BS	001 010	Returns devices to local control Initiates a simultaneous action by responding devices

The timing diagram illustrates the handshake process by indicating the actual waveforms on the DAV, NRFD, and NDAC lines. The NRFD and NDAC signals each represent composite waveforms resulting from two or more Listeners accepting the same data byte at slightly different times. This is usually due to variations in the transmission path length and individual instrument response rates (delay).

The subscripted letters on the timing diagram refer to the same event on the list of events.

HANDSHAKE line timing diagram for one talker and multiple listeners using the handshake process. Two cycles of the handshake sequence are shown. Also refer to the flow diagram and list of events on this figure.



List of Events for Handshake Process

P_1 — Source initializes DAV to high (False—data not valid).

— Acceptors initialize NRFD to low (True—none are ready for data), and set NDAC to low (True—none have accepted the data).

T_1 Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines.

Figure 3-13. Handshake Timing Sequence.

P_2	Source delays to allow data to settle on DIO lines
T_2	Acceptors have all indicated readiness to accept first data byte; NRFD goes high.
T_3	When the data is settled and valid, and the source has sensed NRFD high, DAV is set low.
T_4	First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data. Other acceptors follow at their own rates.
T_5	First acceptor sets NDAC high to indicate that it has accepted the data (NDAC remains low due to other acceptors driving NDAC low).
T_6	Last acceptor sets NDAC high to indicate that it has accepted and NDAC goes high.
T_7	Source, having sensed that NDAC is high, sets DAV high. This indicates to the acceptors that data on the DIO lines must now be considered not valid. Upon completion of this step, one byte has been transferred.
P_3 (T_7—T_{10})	Source changes data on the DIO lines.
T_8*	Acceptors, upon sensing DAV high set NDAC low in preparation for next cycle. NDAC goes low as the first acceptor sets it low.
T_9	First acceptor indicates that it is ready for the next data byte by setting NRFD high. (NRFD remains low due to other acceptors driving NRFD low).
T_{10}	Source checks for error condition (both NRFD and NDAC high), then places data byte on DIO lines (as at T_1).
P_4 (T_{10}—T_{12})	Source delays to allow data to settle on DIO lines.
T_{11}	Last acceptor indicates that it is ready for the next data byte by setting NRFD high; NRFD signal line goes high.
T_{12}	Source, upon sensing NRFD high, sets DAV low to indicate that data on DIO lines is settled and valid.
T_{13}	First acceptor sets NRFD low to indicate that it is no longer ready, then accepts the data.
T_{14}	First acceptor sets NDAC high to indicate that it has accepted the data.
T_{15}	Last acceptor sets NDAC high to indicate that it has accepted the data (as at T_6).
T_{16}	Source, having sensed that NDAC is high, sets DAV high (as at T_7).
T_{17}	Source removes data byte from DIO signal lines after setting DAV high.
T_{18}*	Acceptors, upon sensing DAV high, set NDAC low in preparation for next cycle.
	*Note that all three handshake lines return to their initialized states, as at T_1 and T_2.

Figure 3-13. Handshake Time Sequence (Cont'd).

3-50. Data Lines.

3-51. A set of eight interface lines is available to carry all seven bit interface messages and device dependent messages. These are DATA INPUT OUTPUT lines, DIO1 through DIO8. Only seven lines are required for transfer of data. The eighth line is usually used for a parity check. The data on the DIO lines is transferred in a bit parallel, byte serial form, asynchronously and bidirectionally.

a. Data Mode -

When ATN (attention) goes high (false), the HP-IB is in the "Data Mode". In this mode data may be transferred between devices that were addressed when the HP-IB was in Command Mode. Messages that can be transferred in Data Mode include:

1. Programming Instructions -

Codes are seven bit bytes placed on the HP-IB data (DIO) lines. The meaning of each byte is device dependent and is selected by the equipment designer. These types of messages are usually between the controller acting as the talker and a single device that has been addressed as a listener. The 3438A is not designed to accept programming instructions. All function and range information must be entered via the front panel.

2. Data Codes -

Data codes are seven-bit bytes placed on the data lines. The meaning of each byte is device dependent. For meaningful communication to occur, both the talker and listener must agree on the meaning of the codes they use.

3-52. Individual data bytes transmitted on the HP-IB can be described in an octal code. The binary bits are separated into groups of three starting from the right-hand side (see Table 3-5). Within the groups each binary bit is assigned a weight - "1", "2" and "4" respectively. The octal numbers corresponding to each group of bits is the summation of the weights of the binary ones in each group.

NOTE

When seven-bit character ASCII code is used the hundreds group contains only one bit which can take on the octal value of "0" or "1".

3-53. Data Output Format.

3-54. The Data Output Format and Function Codes are shown in Figure 3-14.

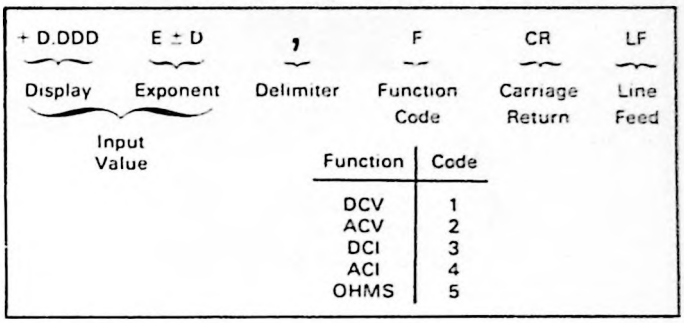
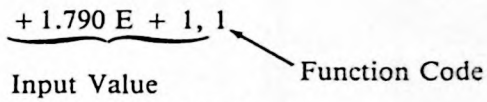


Figure 3-14. Data Output Format and Function Codes.

3-55. The Data Output Format is a fixed length of 13 characters. The Display and Exponent portion combine to relate the actual input value.

Example:

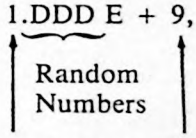
If the Multimeter display reading was + 17.90 V in the dc V function, the output format would be:



NOTE

There is no leading zero suppression.

3-56. Overload Indication. The output format for an Overload Indication is:



Overload Indication

The leading 1 and the +9 exponent signifies an overload indication.

Table 3-5. Octal Code Conversion.

Bits	b_8	b_7	b_6	b_5	b_4	b_3	2	b_1	Octal Code
Weights	"2" (Hundreds)	"1"	"4"	"2"	"1" (Tens)	"4"	"2"	"1" (Ones)	
	1	0	0	1	1	0	1	0	2 3 2
	1	1	1	1	1	0	0	0	3 7 0
	0	1	0	0	1	0	1	1	1 1 3
	0	0	0	1	0	1	1	1	0 2 7

3-57. PROGRAMMING INFORMATION.

3-58. Using the 3438A Multimeter on the HP-IB will be easier if the following three points are remembered:

1. All function and range information must be entered via the front panel. There are no software programming commands.

2. When placed in Remote, the 3438A requires a trigger command before a reading can be taken.

3. If the 3438A is addressed to talk, but is not in Remote, it will take readings without having to receive a trigger command first.

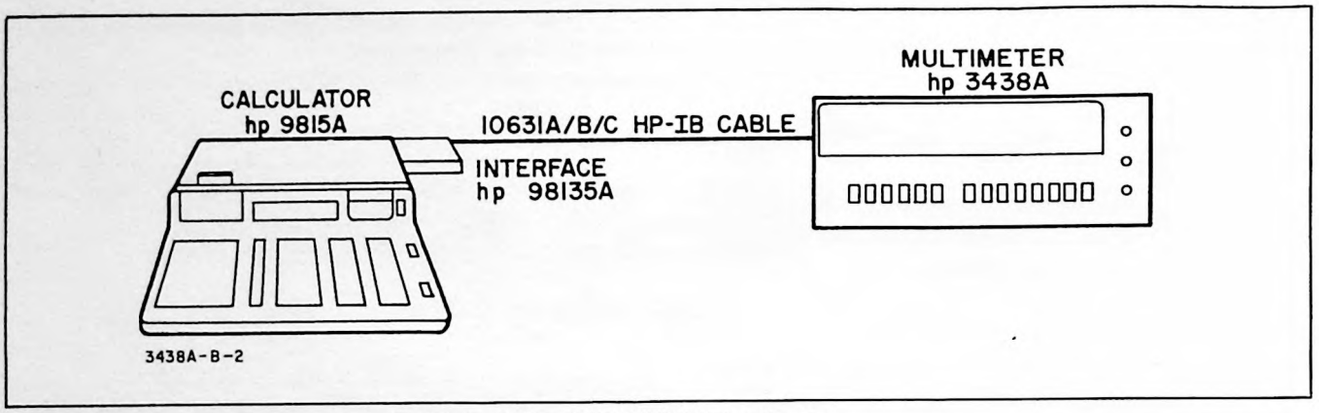


Figure 3-15. 9815A/HP-IB Application.

9815A PROGRAM #1

ENTER 3438A ADDRESS	0000 2 0001 3 0002 ENTER↑
GO TO REMOTE (REN)	0003 CMD 5 0005 @ 0006 B 0007 0008 END∝
PAUSE	0009 1 0010 STO A 0011 2 0012 0 0013 STO F 0014 FOR A→F 0015 PAUSE 0016 NEXT A
3438A ADDRESS	0017 2 0018 3 0019 ENTER↑
TRIGGER 3438A (GET)	0020 CMD 5 0022 @ 0023 H 0024 END∝
INPUT AND PRINT 3438A DATA	0025 2 0026 3 0027 READX 5 0029 X≠Y 0030 SCI 3 0032 PRINT 0033 X≠Y 0034 FIX 0 0036 PRINT 0037 SPACE 0038 GOTO 0017 0040 END

9815A PROGRAM #1 PRINTOUT

```
 2.430  01
    1
```

2.430 01 REPRESENT
$2.43 \times 10^1 = 24.3$ V dc
1 = FUNCTION 1 (dc V)

EXPLANATION

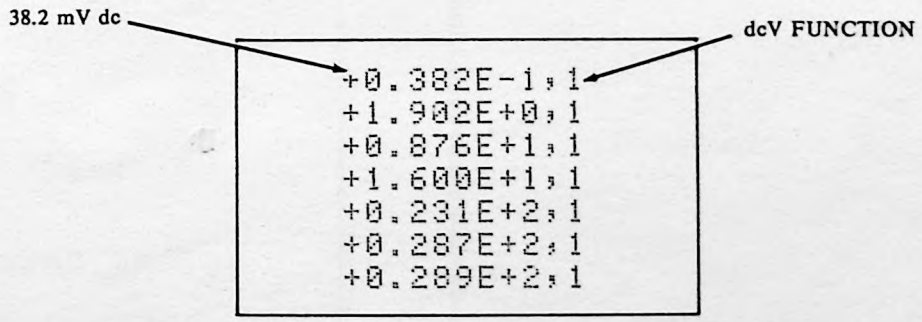
```
 2.220  01
    1
 2.030  01
    1
 1.800  01
    1
 1.540  01
    1
 1.370  01
    1
 1.170  01
    1
 1.000  01
    1
 7.100  00
    1
 6.300  00
    1
 4.000  00
    1
 2.900  00
    1
 1.100  00
    1
 0.000  00
    1
```

9815A PROGRAM #2

```
0000 GOTO    L01
0002 LBL
---- 02
0004 PRNTα
0006 -
0007 0
0008 .
0009 5
0010 1
0011 3
0012 E
0013 +
0014 1
0015 ,
0016 1
0017
0018
0019 ENDα
0020 RETURN
0021 LBL
---- 01
0023 2
0024 3
0025 ENTER↑
0026 CMD     5
0028 @
0029 B
0030
0031 ENDα
0032 1
0033 STO     A
0034 2
0035 0
0036 STO     F
0037 FOR     A→F
0038 PAUSE
0039 NEXT    A
```

```
0040 2
0041 3
0042 ENTER↑
0043 CMD     5
0045 @
0046 H
0047 ENDα
0048 2
0049 3
0050 ENTER↑
0051 1
0052 3
0053 ENTER↑
0054 1
0055 ENTER↑
0056 0
0057 INPUT   5
0059 6
0060 ENTER↑
0061 1
0062 3
0063 ENTER↑
0064 1
0065 ENTER↑
0066 0
0067 STR→α   5
0069 GOSUB   L02
0071 1
0072 STO     A
0073 2
0074 5
0075 STO     F
0076 FOR     A→F
0077 PAUSE
0078 NEXT    A
0079 GOTO    0040
0081 END
```

9815 PROGRAM #2 PRINTOUT



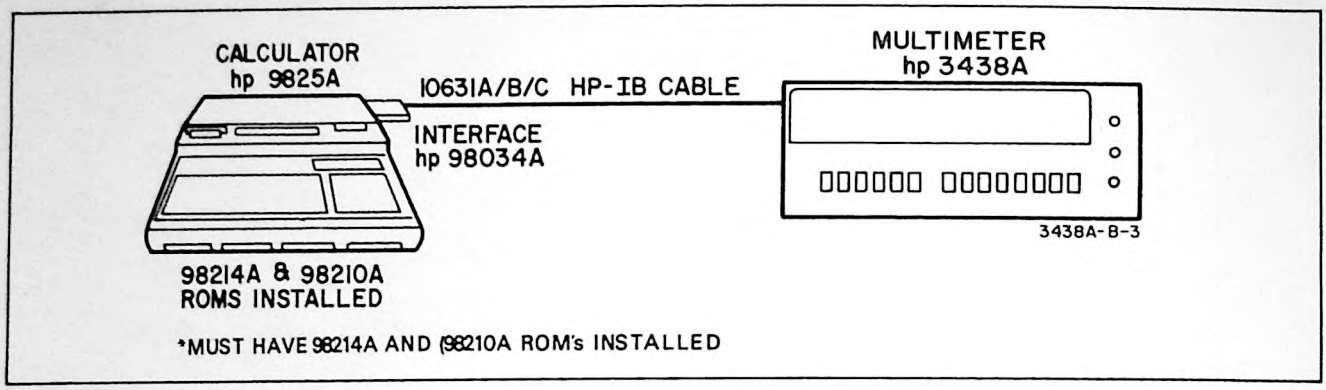


Figure 3-16. 9825A/HP-IB Application.

9825A PROGRAM #1

```
0: 723→D
1: rem D
2: wait 4000
3: "A":trg D
4: fxd 4
5: red D,V,F
6: prt V
7: fxd 0
8: prt F;spc
9: wait 1000
10: gto "A"
11: end
*8517
```

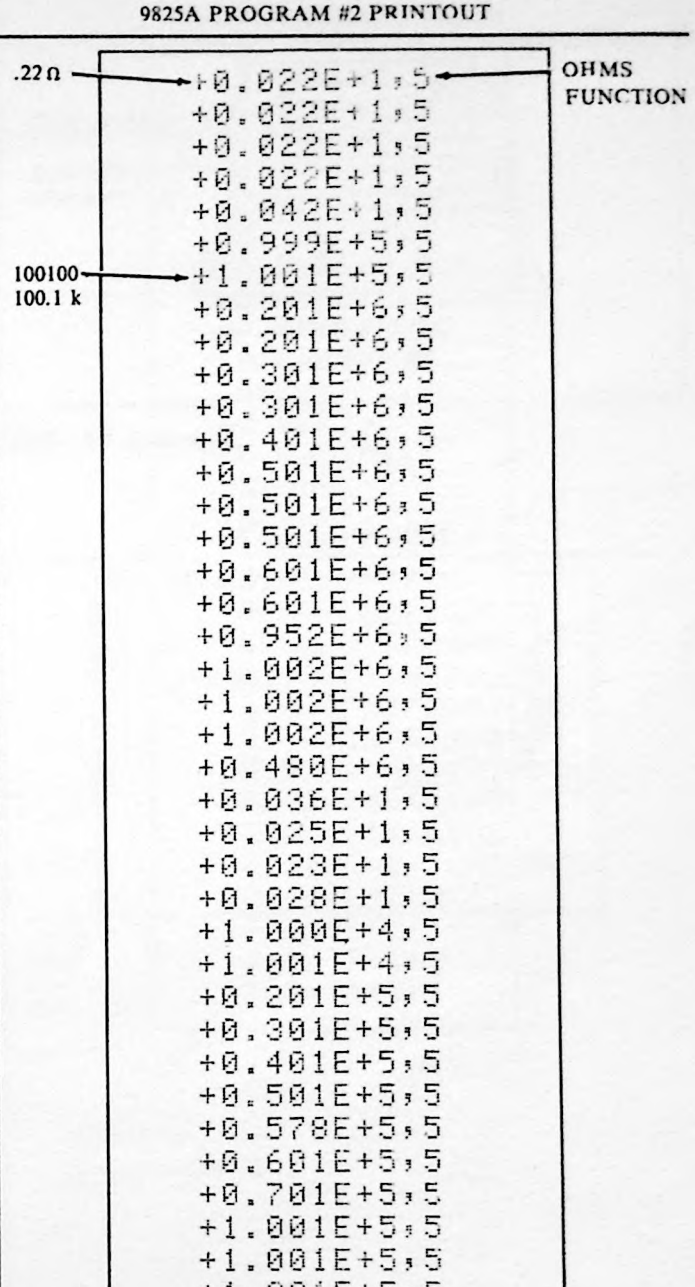
9825A PROGRAM #1 PRINTOUT

```
 3010.0000   ← 3010Ω
       5     ← OHMS FUNCTION

 4010.0000
       5

 6010.0000
       5

 7010.0000
       5

 8010.0000
       5

 9010.0000
       5

10010.0000
       5

20100.0000
       5

30100.0000
       5

40100.0000
       5

50100.0000
       5

60100.0000
       5

110100.0000
       5
```

9825A PROGRAM #2

```
0: dim D$[13]
1: 723→D
2: rem D
3: wait 4000
4: "A":trg D
5: red D,D$
6: prt D$
7: wait 500
8: gto "A"
9: end
*18187
```

9825A PROGRAM #2 PRINTOUT




```
+0.022E+1,5
+0.022E+1,5
+0.022E+1,5
+0.022E+1,5
+0.042E+1,5
+0.999E+5,5
+1.001E+5,5
+0.201E+6,5
+0.201E+6,5
+0.301E+6,5
+0.301E+6,5
+0.401E+6,5
+0.501E+6,5
+0.501E+6,5
+0.501E+6,5
+0.601E+6,5
+0.601E+6,5
+0.952E+6,5
+1.002E+6,5
+1.002E+6,5
+1.002E+6,5
+0.480E+6,5
+0.036E+1,5
+0.025E+1,5
+0.023E+1,5
+0.028E+1,5
+1.000E+4,5
+1.001E+4,5
+0.201E+5,5
+0.301E+5,5
+0.401E+5,5
+0.501E+5,5
+0.578E+5,5
+0.601E+5,5
+0.701E+5,5
+1.001E+5,5
+1.001E+5,5
+1.001E+5,5
+1.002E+5,5
+1.736E+9,5
+1.739E+9,5
```

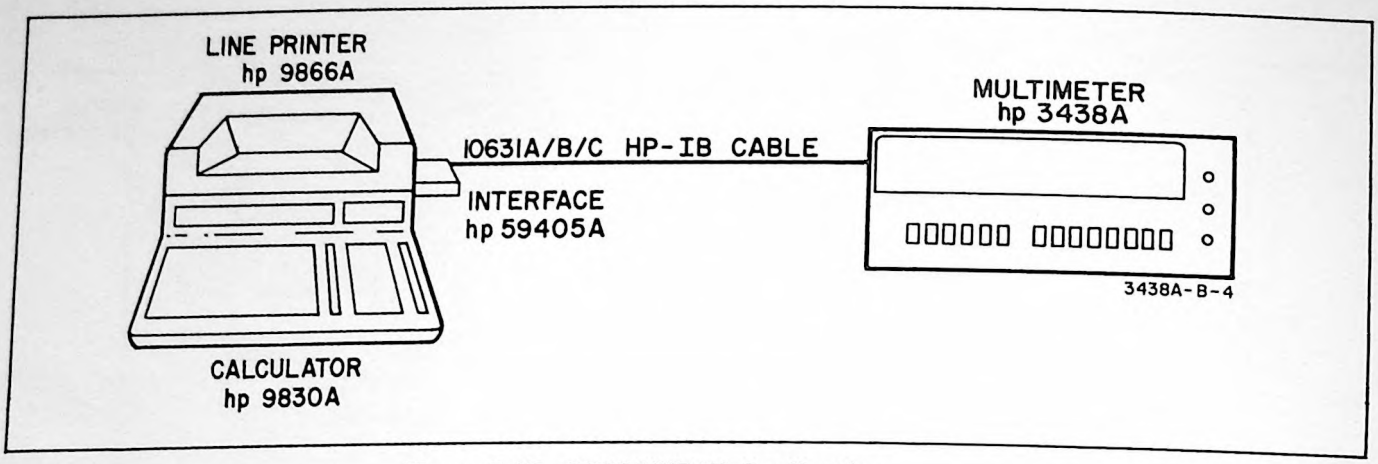


Figure 3-17. 9830A/HP-IB Application.

9830A PROGRAM #1

```
10 CMD "?U"
20 FORMAT B
30 OUTPUT (13,20)1024;
40 CMD "5W"
50 DIM A$[13]
60 ENTER (13,20)A$
70 PRINT A$
80 GOTO 60
90 END
```

9830A PROGRAM #1 PRINTOUT

+ 28.6 V dc → +0.286E+2,1 ← dcV FUNCTION

```
+0.286E+2,1
+0.286E+2,1
+0.286E+2,1
+0.286E+2,1
+0.284E+2,1
+0.280E+2,1
+0.274E+2,1
+0.264E+2,1
+0.255E+2,1
+0.248E+2,1
+0.241E+2,1
+0.235E+2,1
+0.230E+2,1
+0.221E+2,1
+0.213E+2,1
+0.206E+2,1
+0.198E+2,1
+0.193E+2,1
+0.187E+2,1
+0.181E+2,1
+1.580E+1,1
+1.542E+1,1
+1.509E+1,1
+1.469E+1,1
+1.430E+1,1
+1.386E+1,1
+1.343E+1,1
+1.289E+1,1
+1.231E+1,1
+1.161E+1,1
+1.105E+1,1
+1.042E+1,1
+0.969E+1,1
+0.932E+1,1
+0.903E+1,1
```

9830A PROGRAM #2

```
   10 DIM A$[13]
1 ┌20 FOR I=1 TO 30
  │30 CMD "?U7"
2 ┌40 FORMAT B
  └50 OUTPUT (13,40)256,8,512;
3 ┌60 CMD "5W"
4 ┌70 ENTER (13,40)A$
  └80 PRINT A$
   90 NEXT I
   100 END
```

1 = TAKE 30 TRIGGERED READINGS

2 = GROUP EXECUTE TRIGGER

3 = 3438A ADDRESSED TO TALK

4 = SEND READING TO 9830A AND PRINT RESULT

9830A PROGRAM #2 PRINTOUT

```
-0.000E+2,1
-0.000E+2,1
+0.000E+2,1
-0.000E+2,1
-0.000E+2,1
+0.000E+2,1
-0.000E+2,1
-0.000E+2,1
+0.000E+2,1
-0.000E+2,1
-0.000E+2,1
-0.000E+2,1
-0.000E+2,1
-0.000E+2,1
+0.000E+2,1
+0.000E+2,1
+0.000E+2,1
-0.000E+2,1
+0.000E+2,1
-0.000E+2,1
+0.000E+2,1
+0.000E+2,1
+0.000E+2,1
+0.000E+2,1
+0.000E+2,1
-0.000E+2,1
+0.000E+2,1
+0.000E+2,1
+0.000E+2,1
+0.000E+2,1
```

Table 4-1. Test Equipment Required.

Instrument Type	Required Characteristics	Recommended Model
AC Calibrator/High Voltage Amplifier	Frequency: 20 Hz to 100 kHz Output: 10 mV to 1000 V Accuracy (mid band): ± 0.1%	-hp- 745A/746A
DC Standard	Output: 1 mV to 1000 V Accuracy: ± 0.02%	-hp- 740B
Meter Calibrator	Output: 1 A Accuracy: ± 0.1%	-hp- 6920B
Electronic Counter	Frequency: 50 and 60 Hz Accuracy: ± 0.01%	-hp- 5300A/5302A
Resistor Decade Box	1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ and 1 MΩ steps Accuracy: ± 0.005%	General Radio Mdl GR 1433-H
Resistors	1 Ω ± 0.02% 10 Ω ± 0.01% 1 kΩ ± 0.01% 10 kΩ ± 0.01% 100 kΩ ± 0.01% 1 MΩ ± 0.01% 10 MΩ ± 0.1% 22 kΩ ± 1%	G.R. 1440-9601 G.R. 1440-9611 G.R. 1440-9631 G.R. 1440-9641 G.R. 1440-9651 G.R. 1440-9661 0698-8194 0757-1087

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION.

4-2. This section of the manual explains the Performance Tests used to verify the specifications listed in Section I, Table 1-1. A Performance Test Card is at the end of this section for recording the results of these tests.

4-3. Test Equipment Required.

4-4. Equipment required for the Performance Tests is listed in Table 4-1. Equipment that satisfies the critical specifications given in the table may be substituted for a recommended model. Test equipment set-ups are shown for each Performance Test.

4-5. PERFORMANCE TESTS.

4-6. The Performance Tests will be described in the following sequence:

a. DC Voltmeter Accuracy Test.

b. AC Voltmeter Accuracy Test.

c. DC Ammeter Accuracy Test.

d. AC Ammeter Accuracy Test.

e. Ohmmeter Accuracy Test.

f. ACV Normal Mode Rejection Test.

g. ACV Common Mode Rejection Test.

4-7. Abbreviated Performance Tests. Each Performance Test has an associate table that gives the Multimeter and test equipment settings, and the Multimeter display tolerances. Within each table, certain tests are highlighted by bold type. These tests comprise the Abbreviated Performance Tests. The Abbreviated Performance Tests should be used to verify a repair. The complete Performance Test is used to certify the Multimeter performance.

4-8. DC Voltmeter Accuracy Test.

CAUTION

To avoid possible damage to the Multimeter circuitry, the dc input voltage must not exceed 1200 V (dc+peak ac).

4-9. A DC Standard is required for this test.

a. Set the Multimeter to dc volts and 20 mV range.

b. Allow the Multimeter to warm up for 15 minutes.

c. Connect the DC Standard to the VΩ and COM terminals as shown in Figure 4-1.

d. Check all the ranges listed in Table 4-2 for the tolerances indicated.

Table 4-2. DC Voltmeter Accuracy Test.

Range	DC Standard Output	Multimeter Display Limits
*200 mV	+ 1.9 V	19.8 to 20.2 mV
	+ 5.0 V	49.8 to 50.3 mV
	−10.0 V	−99.7 to −100.3 mV
	−19.0 V	**−189.6 to −190.4 mV**
2 V	−.19 V	−.189 to −.191 V
	−.50 V	−.499 to −.502 V
	+ 1.0 V	.998 to 1.002 V
	+ 1.9 V	**1.897 to 1.903 V**
20 V	+ 1.9 V	1.89 to 1.91 V
	+ 5.0 V	4.99 to 5.02 V
	−10.0 V	−9.98 to −10.02 V
	± 19.0 V	**± 18.97 to ± 19.03 V**
200 V	−19.0 V	−18.9 to −19.1 V
	−50.0 V	−49.9 to −50.2 V
	+ 100.0 V	99.8 to 100.2 V
	+ 190.0 V	**189.7 to 190.3 V**
1200 V	**−190.0 V**	**−189 to −191 V**
	+ 500.0 V	499 to 502 V
	+ 1000.0 V	998 to 1002 V

NOTE: Abbreviated Performance Tests are in bold type.

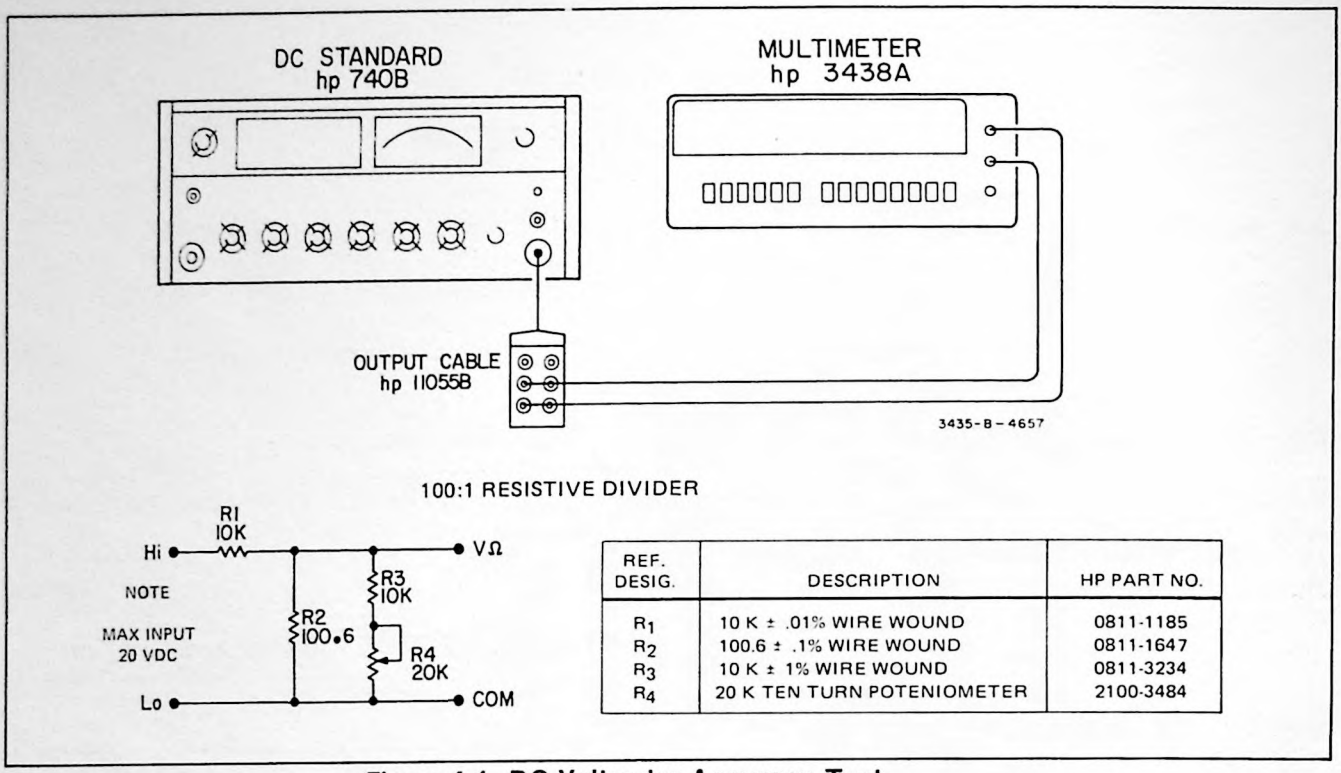
*On the 200 mV Range a 100:1 resistive divider is used with the DC Standard output voltage to provide the needed accuracy.

4-10. AC Voltmeter Accuracy Test.

4-11. An AC Calibrator and High Voltage Amplifier will be required for this test.

CAUTION

To avoid possible damage to the Multimeter circuitry, the ac input voltage must not exceed 600 Vdc or 1700 V (dc + peak ac).



REF. DESIG.	DESCRIPTION	HP PART NO.
R_1	10 K ± .01% WIRE WOUND	0811-1185
R_2	100.6 ± .1% WIRE WOUND	0811-1647
R_3	10 K ± 1% WIRE WOUND	0811-3234
R_4	20 K TEN TURN POTENIOMETER	2100-3484

Figure 4-1. DC Voltmeter Accuracy Test.

a. Set the Multimeter to acV.

b. Connect the AC Calibrator as shown in Figure 4-2.

c. Check the ranges and frequencies listed in Table 4-3 for the tolerances indicated on all ranges through 200 V (100 V input).

WARNING

Use extreme care when checking the following ranges. Establish all connections before turning on the high voltage source. When the tests are completed, turn off the high voltage before disconnecting any cables or test leads.

d. To check the 1200 V range and the 190 V input to the 200 V range, connect the High Voltage Amplifier to the Multimeter and check the tolerances indicated.

4-12. DC Ammeter Accuracy Test.

4-13. This test requires the use of a power supply, a DC Standard and a precision resistor listed in Table 4-4 (part numbers are given in Table 4-1) or a resistor decade box.

a. Connect the Multimeter and test equipment as shown in Figure 4-3.

b. Connect the 100 kilohm ± 0.01% resistor in the R_A position as shown.

Table 4-3. AC Voltmeter Accuracy Test.

Range	AC Calibrator Output	Test Frequency	Multimeter Display Limits
200 mV	**20 mV**	**30 Hz**	**19.4 to 20.6 mV**
	20 mV	50 Hz	19.6 to 20.4 mV
	20 mV	20 kHz	19.6 to 20.4 mV
	50 mV	100 kHz	48.3 to 51.8 mV
	50 mV	30 Hz	49.0 to 51.1 mV
	50 mV	20 kHz	49.6 to 50.5 mV
	100 mV	30 Hz	98.2 to 101.8 mV
	100 mV	50 Hz	99.4 to 100.6 mV
	100 mV	50 kHz	97.5 to 102.5 mV
	.19 V	30 Hz	186.9 to 193.2 mV
2 V	.2 V	30 Hz	.194 to .206 mV
	1.9 V	**100 kHz**	**.862 to 1.939 V**
	1 V	20 kHz	.994 to 1.006 V
20 V	2 V	30 Hz	1.94 to 2.06 V
	2 V	50 Hz	1.96 to 2.04 V
	2 V	**200 Hz**	**1.96 to 2.04 V**
	2 V	**10 kHz**	**1.96 to 2.04 V**
	5 V	20 kHz	4.96 to 5.05 V
	5 V	50 kHz	4.83 to 5.18 V
	19 V	**200 Hz**	**18.91 to 19.09 V**
	19 V	**10 kHz**	**18.91 to 19.09 V**
	19 V	**100 kHz**	**18.62 to 19.39 V**
200 V	20 V	20 kHz	19.6 to 20.4 V
	100 V	50 Hz	19.4 to 100.6 V
	***190 V**	**30 Hz**	**186.9 to 193.2 V**
1200 V	***200 V**	**20 kHz**	**196 to 204 V**
	*500 V	30 Hz	490 to 511 V
	*1000 V	10 kHz	994 to 1006 V

NOTE: Abbreviated Performance Tests are in bold type.

* . . . Use 746A Output.

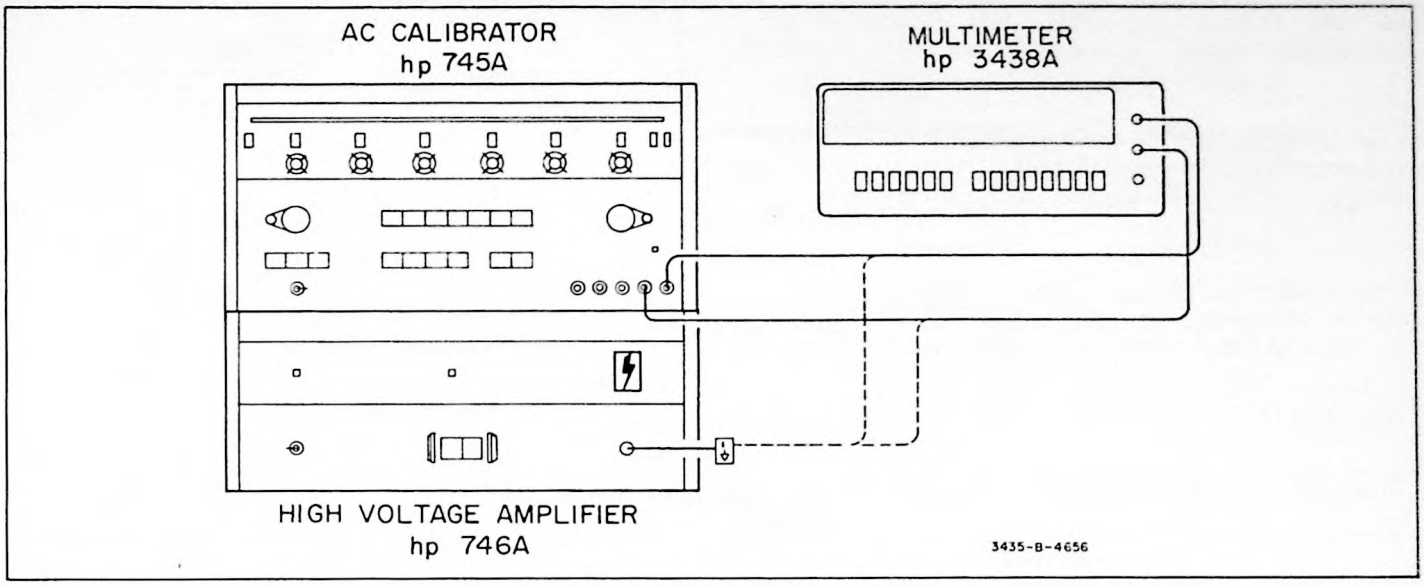


Figure 4-2. AC Voltage Accuracy Test.

c. Set the Multimeter function to ⎓ mA and range to 200 μ A.

d. Check all the Multimeter ranges, using the values of R_A and differential voltmeter readings shown in Table 4-4. The Multimeter display should indicate within the limits provided.

Table 4-4. DC Ammeter Accuracy.

Range	Current Level	R_A	Differential VM Reading	Multimeter Display Limits
200 μA	10 μA	100 kΩ	1.0000 V	9.8 to 10.2 μA
	50 μA	± 0.01%	5.0000 V	49.7 to 50.4 μA
	100 μA		**10.000 V**	**99.5 to 100.5 μA**
2 mA	.1 mA	1 kΩ	.10000 V	.098 to .102 mA
	.5 mA	± 0.01%	.50000 V	.497 to .504 mA
	1 mA		**1.0000 V**	**.995 to 1.005 mA**
20 mA	1 mA	1 kΩ	1.0000 V	.98 to 1.02 mA
	5 mA	± 0.01%	5.0000 V	4.97 to 5.04 mA
	10 mA		**10.000 V**	**9.95 to 10.05 mA**
200 mA	10 mA	10 Ω	.10000 V	9.8 to 10.2 mA
	50 mA	± 0.01%	.5000 V	49.7 to 50.4 mA
	100 mA		**1.0000 V**	**99.5 to 100.5 mA**
2000 mA	100 mA	1Ω	.10000 V	97 to 103 mA
	500 mA	± 0.02%	.50000 V	495 to 505 mA
	800 mA		**.80000 V**	**793 to 807 mA**

NOTE: Abbreviated Performance Tests are in bold type.

4-14. AC Ammeter Accuracy Test.

4-15. An AC Calibrator and AC Current Source are required for this test.

a. Connect the equipment as shown in Figure 4-4 using the decade resistor box to select the value of R_A. Set the Multimeter function to ~mA. Using the values of R_A and AC Calibrator outputs shown in Table 4-5, check the 200 μ A, 2 mA and 20 mA Multimeter ranges at the frequencies listed.

b. To check the 200 mA and 2000 mA ranges, it will be necessary to use an ac current source. Connect the ac current source to the Multimeter as shown in Figure 4-5.

c. Check the Multimeter 200 mA and 2000 mA ranges for the tolerances listed in Table 4-6.

4-16. Ohmmeter Accuracy Test.

4-17. A precision resistive decade box is required for this test. This resistive decade should be calibrated to within a tolerance of ± .005%.

a. Set the Multimeter to the kΩ function and the 20Ω range.

b. Connect the equipment as shown in Figure 4-6.

Table 4-5. AC Ammeter Accuracy Test (200 μ A Thru 20 mA Ranges).

Range	AC Calibrator Output Level	AC Calibrator Frequency	R_A Value	Current Level	Multimeter Display Limits
200 μA	2.02 V	100 Hz	100 kΩ ± .1%	20 μA	19.4 to 20.6 μA
2 mA	20.02 V	100 Hz	100 kΩ ± .1%	.2 mA	.194 to .206 mA
20 mA	20.02 V	100 Hz	10 kΩ ± 0.1%	2 mA	1.94 to 2.06 mA

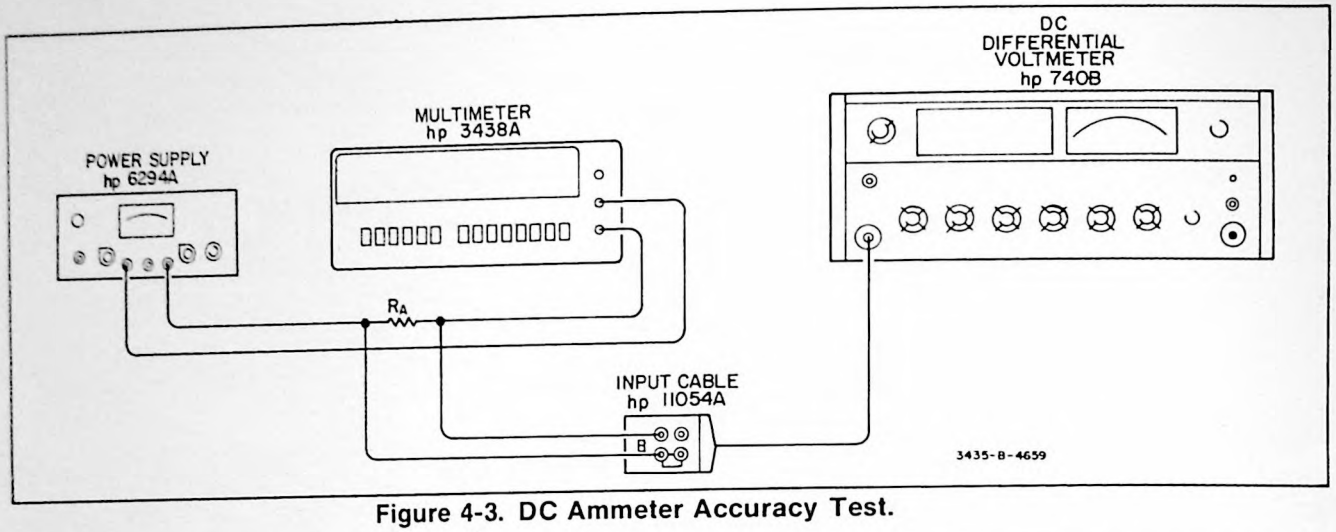


Figure 4-3. DC Ammeter Accuracy Test.

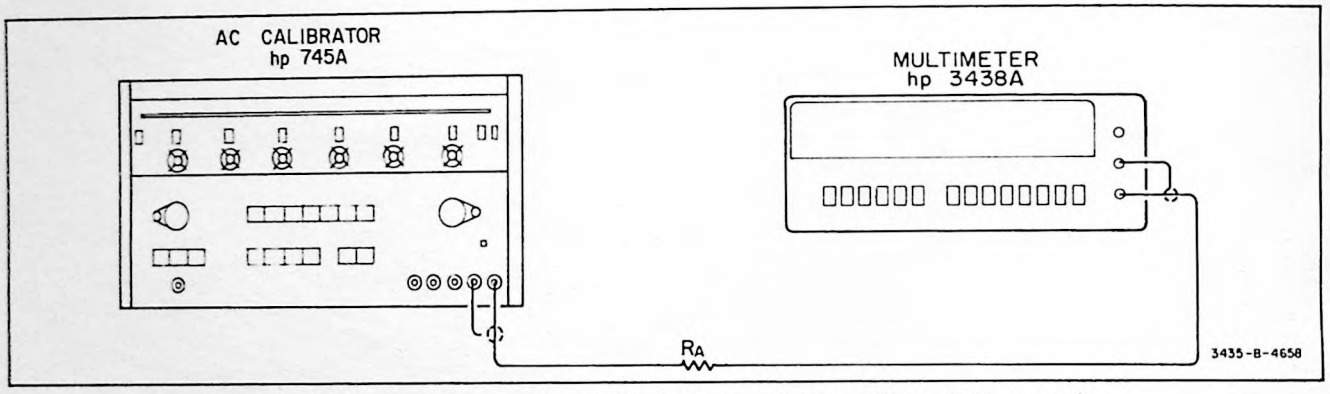


Figure 4-4. AC Ammeter Accuracy Test (200 μ A Thru 20 mA Ranges).

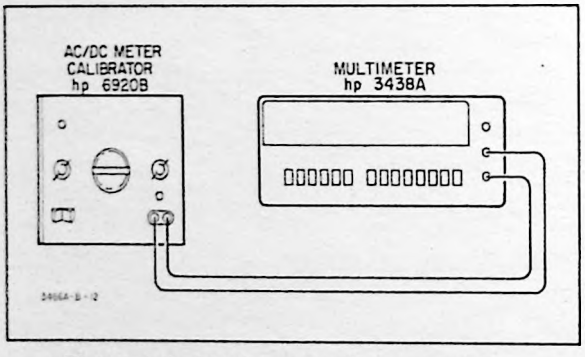


Figure 4-5. AC Ammeter Accuracy Test (200 mA and 2000 mA Ranges).

Table 4-6. AC Ammeter Accuracy Test (200 mA and 200 mA Ranges)

Range	AC Current Source Output	Multimeter Display Limits
200 mA	20 mA	19.4 to 20.5 mA
	50 mA	49.2 to 50.9 mA
	100 mA	98.7 to 101.3 mA
2000 mA	200 mA	194 to 206 mA
	500 mA	490 to 510 mA
	1000 mA	984 to 1016 mA

Table 4-7. Ohmmeter Accuracy Test.

Range	Standard Resistance	Multimeter Display Limits
20 Ω	1 Ω	.90 to 1.11 Ω
	10 Ω	9.85 to 10.15 Ω
	19 Ω	**18.81 to 19.20 Ω**
200 Ω	19 Ω	18.8 to 19.2 Ω
	50 Ω	49.7 to 50.3 Ω
	190 Ω	**189.4 to 190.6 Ω**
2 kΩ	190 Ω	.188 to .192 kΩ
	1 kΩ	.996 to 1.004 kΩ
	1.9 kΩ	**1.894 to 1.906 kΩ**
20 kΩ	1.9 kΩ	1.88 to 1.92 kΩ
	5 kΩ	4.97 to 5.03 kΩ
	19 kΩ	**18.94 to 19.06 kΩ**
200 kΩ	19 kΩ	18.8 to 19.2 kΩ
	100 kΩ	99.6 to 100.4 kΩ
	190 kΩ	**189.4 to 190.6 kΩ**
2000 kΩ	190 kΩ	188 to 192 kΩ
	500 kΩ	497 to 503 kΩ
	1.9 MΩ	**1894 to 1906 kΩ**
20 MΩ	1.9 MΩ	1.86 to 1.94 MΩ
	5 MΩ	4.94 to 5.06 MΩ
	10 MΩ	**9.90 to 10.10 MΩ**

NOTE: Abbreviated Performance Tests are in bold type.

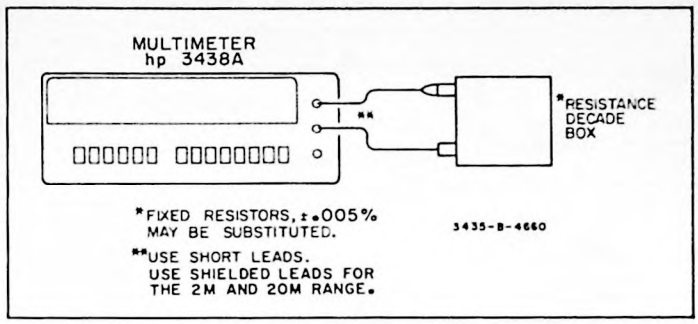


Figure 4-6. Ohms Accuracy Test.

c. Set the resistive decade to zero ohms.

d. Check all ranges listed in Table 4-7 for the tolerances indicated.

4-18. AC Normal-Mode Rejection Test.

4-19. The purpose of the test is to verify the ability of the Multimeter to make accurate DC Voltage measurements in the presence to AC Voltage at power line frequencies.

Definition: AC Normal-Mode Rejection is the ratio of the peak normal-mode voltage to the resultant error in reading.

$$\text{NMRR (dB)} = 20 \log_{10} \left[\frac{\text{Peak AC Interfering Voltage}}{\text{Change in DCV reading (i.e., peak roll)}} \right]$$

4-20. An AC Calibrator and Electronic Counter are required for this test.

a. Connect the test equipment as shown in Figure 4-7. Do not connect the Multimeter at this time.

b. Using the Electronic Counter as a monitor, adjust the AC Calibrator frequency to 60 Hz ± 0.1% (Period - 16650 to 16683 μs).

c. Set the Multimeter function to dcV (⎓V) and range to 20 V. Short the Multimeter input and note the indication.

d. Disconnect the short and connect the AC Calibrator to the Multimeter input. Adjust the Calibrator output to 7.07 V rms (10 V peak).

e. The Multimeter indication should not vary more than 0.10 V or 10 digits peak from the indication noted in Step c. This verifies an AC Normal-Mode Rejection of 40 dB.

f. Repeat Steps c, d, and e for an AC Calibrator output frequency of 50 Hz ± 0.1% as monitored by the Electronic Counter (Period = 19980 to 20020 μs).

4-21. AC Common Mode Rejection Ratio - CMRR.

4-22. The purpose of this test is to verify the ability of the Multimeter to make accurate AC Voltage measurements at power line frequencies applied simultaneously to the V - Ω and COM terminals.

Definition: CMRR (dB) =

$$20 \log_{10} \left[\frac{\text{RMS AC Interfering Voltage}}{\text{Change in ACV reading}} \right]$$

4-23. An AC Calibrator and Electronic Counter are required for this test.

a. Conncet the AC Calibrator to the electronic counter and adjust for a frequency of 50 Hz ± 0.1% (19,980 μs to 20,020 μs).

b. Set the AC Calibrator for an output of 10 V rms.

c. Set the Multimeter to the ACV function and the 2 V range. Connect a 1 K ± 1% resistor between V - Ω and COM terminals at the Multimeter front panel.

d. Connect the AC Calibrator between the Multimeter V - Ω terminal (with the 1 K resistor still in place) and power line ground as shown in Figure 4-8.

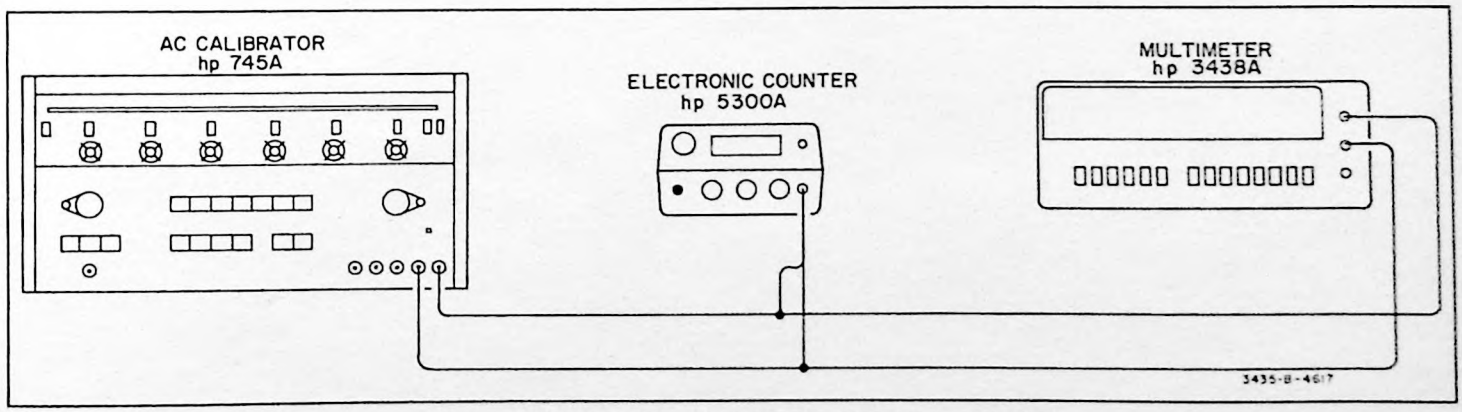


Figure 4-7. AC Normal-Mode Rejection Test.

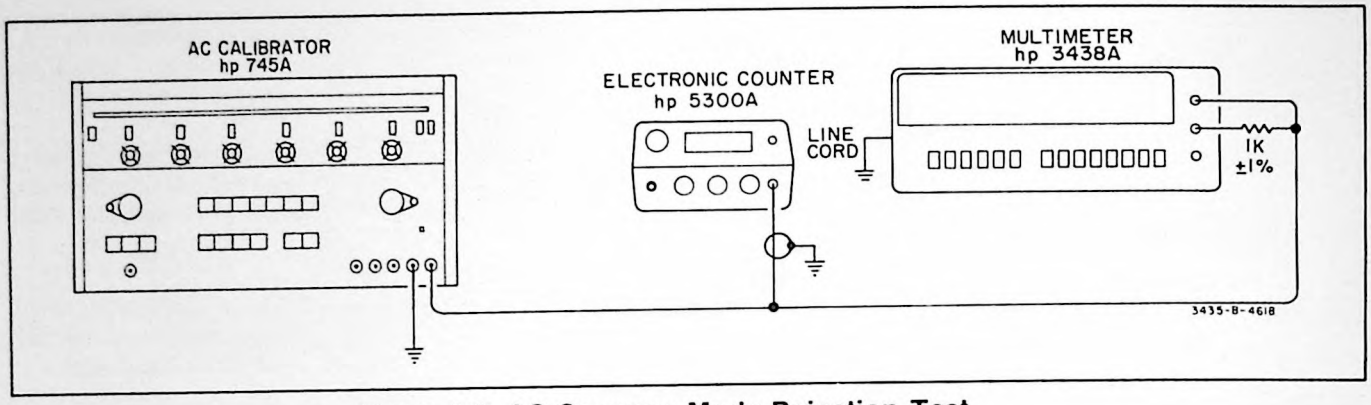


Figure 4-8. AC Common-Mode Rejection Test.

e. The reading on the Multimeter should not change by more than 0.010 V or 10 digits from the reading noted in Step c in order to verify and AC Common-Mode Rejection of $\geqslant 60$ dB.

f. Repeat Steps c and d with the frequency adjusted to 60 Hz $\pm$ 0.1% (16,650 μs to 16,683 μs).

Hewlett-Packard Model 3438A

Abbreviated Performance Test Card

Test Performed By _____

Multimeter
Serial No. _____ Date _____

Paragraph Number	Test/Input	Test Limit	Test Results
4-8	DC Voltmeter Accuracy		
	200 mV Range/-190 mV	-189.6 to -190.4 mV	_____
	2 V Range/+ 1.9 V	1.1897 to 1.903 V	_____
	20 V Range/± 19 V	± 18.97 to ± 19.03 V	_____
	200 V Range/+ 190 V	189.7 to 190.3 V	_____
	1200 V Range/-190 V	-189 to -191 V	_____
4-10	AC Voltmeter Accuracy		
	200 mV Range/20 mV, 30 Hz	19.4 to 20.6 mV	_____
	2 V Range/1.9 V, 100 kHz	1.862 to 1.939 V	_____
	20 V Range/2 V, 200 Hz	1.96 to 2.04 V	_____
	20 V Range/2 V, 10 kHz	1.96 to 2.04 V	_____
	20 V Range/19 V, 200 Hz	18.91 to 19.09 V	_____
	20 V Range/19 V, 10 kHz	18.91 to 19.09 V	_____
	20 V Range/19 V, 100 kHz	18.62 to 19.39 V	_____
	200 V Range/190 V, 30 Hz	186.9 to 193.2 V	_____
	1200 V Range/200 V, 20 kHz	196 to 204 V	_____
4-12	DC Ammeter Accuracy		
	200 μA Range/100μA	99.5 to 100.5 μA	_____
	2 mA Range/1 mA	.995 to 1.005 mA	_____
	20 mA Range/10 mA	9.95 to 10.05 mA	_____
	200 mA Range/100 mA	99.5 to 100.5 mA	_____
	2000 mA Range/800 mA	793 to 807 mA	_____
4-16	Ohmmeter Accuracy		
	20 Ω Range/19 Ω	18.81 to 19.20 Ω	_____
	200 Ω Range/190 Ω	189.4 to 190.6 Ω	_____
	2 kΩ Range/1.9 kΩ	1.894 to 1.906 kΩ	_____
	20 kΩ Range/19 kΩ	18.94 to 19.06 kΩ	_____
	200 kΩ Range/190 kΩ	189.4 to 190.6 kΩ	_____
	2000 kΩ Range/1.9 MΩ	1894 to 1906 kΩ	_____
	10 MΩ Range/10 MΩ	9.90 to 10.10 MΩ	_____

Hewlett-Packard Model 3438A Multimeter

Performance Test Card

Test Performed By: _____

Multimeter
Serial No. _____ Data _____

Paragraph Number	Test	Test Limit	Test Results
4-8	DC Voltmeter Accuracy		
	200 mV Range		
	+19 mV	19.8 to 20.2 mV	_____
	+50 mV	49.8 to 50.3 mV	_____
	-100 mV	-99.7 to -100.3 mV	_____
	-190 mV	-189.6 to -190.4 mV	_____
	2 V Range		
	-.19 V	-.189 to -.191 V	_____
	-.50 V	-.499 to -.502 V	_____
	+1 V	.998 to 1.002 V	_____
	+1.9 V	1.897 to 1.903 V	_____
	20 V Range		
	+1.9 V	1.89 to 1.91 V	_____
	+5 V	4.99 to 5.02 V	_____
	-10 V	-99.8 to -10.02 V	_____
	±19 V	±18.97 to ±19.03 V	_____
	200 V Range		
	-19 V	-18.9 to -19.1 V	_____
	-50 V	-49.9 to -50.2 V	_____
	+ 100 V	99.8 to 100.2 V	_____
	+190 V	189.7 to 190.3 V	_____
	1200 V Range		
	-190 V	-189 to -191 V	_____
	+500 V	499 to 502 V	_____
	+1000 V	998 to 1002 V	_____
4-10	AC Voltmeter Accuracy		
	200 mV Range		
	20 mV 30 Hz	19.4 to 20.6 mV	_____
	20 mV 50 Hz	19.6 to 20.4 mV	_____
	20 mV 20 kHz	19.6 to 20.4 mV	_____
	50 mV 100 kHz	48.3 to 51.8 mV	_____
	50 mV 30 Hz	49.0 to 51.1 mV	_____
	200 mV Range		
	50 mV 20 kHz	49.6 to 50.5 mV	_____
	100 mV 30 Hz	98.2 to 101.8 mV	_____
	100 mV 50 Hz	99.4 to 100.6 mV	_____
	100 mV 50 kHz	97.5 to 102.5 mV	_____
	.19 V 30 Hz	186.9 to 193.2 mV	_____

Performance Test Card (Cont'd)

Paragraph Number	Test	Test Limit	Test Results
4-10	AC Voltmeter Accuracy (Cont'd)		
	2 V Range		
	.2 V 30 Hz	.194 to .206 V	_____
	1.9 V 100 kHz	1.862 to 1.939 V	_____
	1 V 20 kHz	.994 to 1.006 V	_____
	20 V Range		
	2V 30 Hz	1.94 to 2.06 V	_____
	2V 50 Hz	1.96 to 2.04 V	_____
	2V 200 Hz	1.96 to 2.04 V	_____
	2V 10 kHz	1.96 to 2.04 V	_____
	5V 20 kHz	4.96 to 5.05 V	_____
	5 V 50 kHz	4.83 to 5.18 V	_____
	19 V 200 Hz	18.91 to 19.09 V	_____
	19 V 10 kHz	18.91 to 19.09 V	_____
	19 V 100 kHz	18.02 to 19.39 V	_____
	200 V Range		
	20 V 20 kHz	19.6 to 20.4 V	_____
	100 V 50 Hz	19.4 to 100.6 V	_____
	190 V 30 Hz	186.9 to 193.2 V	_____
	1200 V Range		
	190 V 20 kHz	196 to 204 V	_____
	500 V 30 Hz	490 to 511 V	_____
	1000 V 10 kHz	994 to 1006 V	_____
4-12	DC Ammeter Accuracy		
	200 μA Range		
	10 μA	9.8 to 10.2μA	_____
	50 μA	49.7 to 50.4 μA	_____
	100 μA	99.5 to 100.5 μA	_____
	2 mA Range		
	.1 mA	.098 to .102 mA	_____
	.5 mA	.497 to .504 mA	_____
	1 mA	.995 to 1.005 mA	_____
	20 mA Range		
	1 mA	.98 to 1.02 mA	_____
	5 mA	4.97 to 5.04 mA	_____
	10 mA	9.95 to 10.04 mA	_____
	200 mA Range		
	10 mA	9.8 to 10.2 mA	_____
	50 mA	49.7 to 50.4 mA	_____
	100 mA	99.5 to 100.5 mA	_____
	2000 mA Range		
	100 mA	97 to 103 mA	_____
	500 mA	495 to 505 mA	_____
	800 mA	793 to 807 mA	_____

Performance Test Card (Cont'd)

Paragraph Number	Test	Test Limit	Test Results
4-14	AC Ammeter Accuracy		
	200 μA Range		
	20 μA 100 Hz	19.4 to 20.6 μA	_____
	2 mA Range		
	.2 mA 100 Hz	.194 to .206 mA	_____
	20 mA Range		
	2 mA 100 Hz	1.94 to 2.06 mA	_____
	200 mA Range		
	20 mA 60 Hz	19.4 to 20.6 mA	_____
	50 mA 60 Hz	49.2 to 50.9 mA	_____
	100 mA 60 Hz	98.7 to 101.3 mA	_____
	2000 mA Range		
	200 mA 60 Hz	194 to 206 mA	_____
	500 mA 60 Hz	490 to 510 mA	_____
	1000 mA 60 Hz	984 to 1016 mA	_____
4-16	Ohmmeter Accuracy		
	*20 Ω Range		
	1 Ω	.90 to 1.11 Ω	_____
	10 Ω	9.85 to 10.15 Ω	_____
	19 Ω	18.81 to 19.20 Ω	_____
	*200 Ω Range		
	19 Ω	18.8 to 19.2 Ω	_____
	50 Ω	4.97 to 50.3 Ω	_____
	190 Ω	189.4 to 190.6 Ω	_____
	*2 kΩ Range		
	190 Ω	.188 to .192 kΩ	_____
	1 kΩ	.996 to 1.004 kΩ	_____
	1.9 kΩ	1.894 to 1.906 kΩ	_____
	20 kΩ Range		
	1.9 kΩ	1.88 to 1.92 kΩ	_____
	5 kΩ	4.97 to 5.03 kΩ	_____
	19 kΩ	18.94 to 19.06 kΩ	_____
	200 kΩ Range		
	19 kΩ	18.8 to 19.2 kΩ	_____
	100 kΩ	99.6 to 100.4 kΩ	_____
	190 kΩ	189.4 to 190.6 kΩ	_____
	*2000 kΩ Range		
	190 kΩ	188 to 192 kΩ	_____
	500 kΩ	497 to 503 kΩ	_____
	1.9 MΩ	1894 to 1906 kΩ	_____

*Subtract lead resistance.

Performance Test Card (Cont'd)

Paragraph Number	Test	Test Limits	Test Results
4-16	Ohmmeter Accuracy (Cont'd)		
	*20 MΩ Range		
	1.9 MΩ	1.86 to 1.94 MΩ	_____
	5 MΩ	4.94 to 5.06 MΩ	_____
	10 MΩ	9.90 to 10.10 MΩ	_____
4-18	AC Normal-Mode Rejection	⩾ 40 dB	_____
4-21	AC Common-Mode Rejection	⩾ 60 dB	_____

*Use shielded test leads.

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

Table 5-1. Test Equipment Required.

Instrument Type	Required Characteristics	Recommended Model
Digital Volt/Ohmmeter	DC Volts: 1 V, 10 V and 100 V range Accuracy: ± 0.04% Input Resistance: 10 MΩ Ohms: 20 kΩ Accuracy: ± 0.07%	-hp- 3465A Multimeter
AC Calibrator	Frequency: 20 Hz to 100 kHz Output: 1 mV to 100 V Accuracy (mid band): ± 0.1%	-hp- 745A
DC Standard	Output: 1 mV to 1000 V Accuracy: ± 0.02%	-hp- 740B
Electronic Counter	Frequency: 50 and 60 Hz Accuracy: ± 0.01%	-hp- 5300A/5302A
Resistor Decade Box	1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ and 1 MΩ steps Accuracy: ± 0.005%	General Radio Mdl GR 1433-H

SECTION V
ADJUSTMENT PROCEDURES

5-1. INTRODUCTION.

5-2. This section of the manual contains Pre-Adjustment and Adjustment Procedures.

5-3. EQUIPMENT REQUIRED.

5-4. The Test Equipment required for these Adjustment Procedures is listed in Table 5-1. Equipment that satisfies the critical specifications given in the table may be substituted for a recommended model.

5-5. ADJUSTMENT INTERVAL.

5-6. Adjustment Procedures should be performed at least once every year to ensure proper calibration of the Multimeter.

WARNING

These Adjustment Procedures are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions or Performance Tests unless you are qualified to do so.

CAUTION

Wear clean cotton gloves when working on the circuit boards or switches. Contamination of fingerprints on high impedance points will degrade the performance of the instrument. Nylon gloves should not be worn due to the possibility of static charge buildup.

CAUTION

The hybrid circuits in the Multimeter may be permanently damaged by static discharge from a hand or tool when the Multimeter is disassembled. The procedures below must be followed to prevent possible damage.

1. Ground the hand while disassembling and working on the Multimeter. Conductive wristbands (-hp- Part No. 00970-67900) are available for this purpose.

2. Attach the Multimeter COM terminal to earth ground. Touch all tools to earth ground to remove static charges before using them on the Multimeter.

3. Use a soldering iron with a grounded tip.

5-7. PRE-ADJUSTMENT PROCEDURES.

5-8. Disassembly Instructions:

a. Disconnect the Multimeter Power Cord.

b. Remove two top cover fastening screws (back panel) and remove top cover.

c. Remove five A3 shield mounting screws (back panel). This will allow the A3 PC and shield assembly (HP-IB) to slide forward ⅛ of an inch.

d. Disconnect W5 from the A3 PC assembly. W5 is a green, yellow, orange, red, brown cable connecting A3 to A2 (display).

e. Remove the A3 PC and shield assembly by sliding the assembly forward and upward. With the Multimeter front panel facing you, place the A3 PC and shield assembly to the right side of the Multimeter.

f. Re-connect W5 to the A3 PC assembly.

g. All adjustments can be made without removing the internal A1 shield.

5-9. Test Point and Adjustment Locations.

5-10. Fold out and refer to Figure 5-4. Adjustment Locator for the remainder of this procedure. The Adjustment Locator shows Test Points, Test Jumpers, Adjustment and Connector locations.

NOTE

The Multimeter should warm up for 15 minutes before performing the Adjustment Procedure.

5-11. ADJUSTMENT PROCEDURE.

5-12. Adjustments should be made in the following sequence:

(1)A +7 V Power Supply Adjustment (R417).

(1)B U725 Back Gate Bias Adjustment (R603).

(2) 10 kHz Clock Frequency Adjustment (R9).

(3) AC Zero Adjustment (R203).

(4) 20 Ω Range Zero Adjustment (R111).

(5) DC Gain Adjustment (R403).

(6) OHMS Gain Adjustment (R119).

(7) AC Gain Adjustment (R123).

(8) 20 V ac Range, 20 kHz Adjustment (R102).

(9) 2 V ac Range 20 kHz Adjustment (R110).

(10) 20 V ac Range 100 kHz Adjustment (C109).

5-13. (1)A +7 V Power Supply Adjustment (R417).

a. Place dc DVM probe tip on the +7 V test pad or + end of C407.

b. Adjust R417 for a dc DVM reading of +7 ±0.01 volts (6.99 to 7.01 volts).

c. Check the power supply voltages listed in Table 5-2 to verify the tolerances indicated.

Table 5-2. Power Supply Voltage Checks.

Power Supply Voltage	Tolerances
-7 V	-6.9 to -7.1 V
-2 V (V SUB)	-1.9 to 2.1 V
+ 6.5 (V DISP)	6.18 to 6.83 V
+ 9 V (V D)	8.55 to 9.45 V
+ 5 V (Vc)	4.75 to 5.25 V

5-14. (1)B U725 Back Gate Bias Adjustment (R603).

a. Connect a dc Digital Voltmeter (DVM) to JMVB (A3 PC assembly).

b. Adjust R603 for a dc DVM reading equal to the voltage stamped on A3U725.

NOTE

The voltage stamped on A3U725 will be within the limits of —2 V dc to —5 V dc.

5-15. (2) Clock Frequency Adjustment (R9).

a. Connect a 10 MΩ (10:1 divider) oscilloscope probe from the 5300A/5302A frequency counter input to JM2 on the Multimeter A1 PC assembly.

b. Adjust R9 for a frequency counter reading of 9980 Hz to 10020 Hz (10 kHz ±.2%).

5-16. (3) AC Zero Adjustment (R203).

a. Set the Multimeter to ac V, 20 V range.

b. Connect a short across the V/Ω to COM terminals.

c. Adjust R203 for a Multimeter display reading of 0.00 V."

5-17. (4) 20 Ohms Zero Adjustment (R111).

a. Set the Multimeter to ac V 200 V range.

b. Connect a short across the V/Ω to COM terminals.

NOTE

Use a low resistance short comprised of heavy copper wire soldered across a double banana connector.

c. Adjust R111 for a Multimeter display reading of 00.0 ohms.

5-18. (5) DC Gain Adjustment (R403).

a. Set the Multimeter to dc V, 20 V range.

b. Set the 740B dc standard as follows:

Function	Std
Range	100 V
Output voltage	19.000 (V)

c. Connect the 740B output to the Multimeter input as shown in Figure 5-1.

d. Adjust R403 for a Multimeter display reading of 19.00 V.

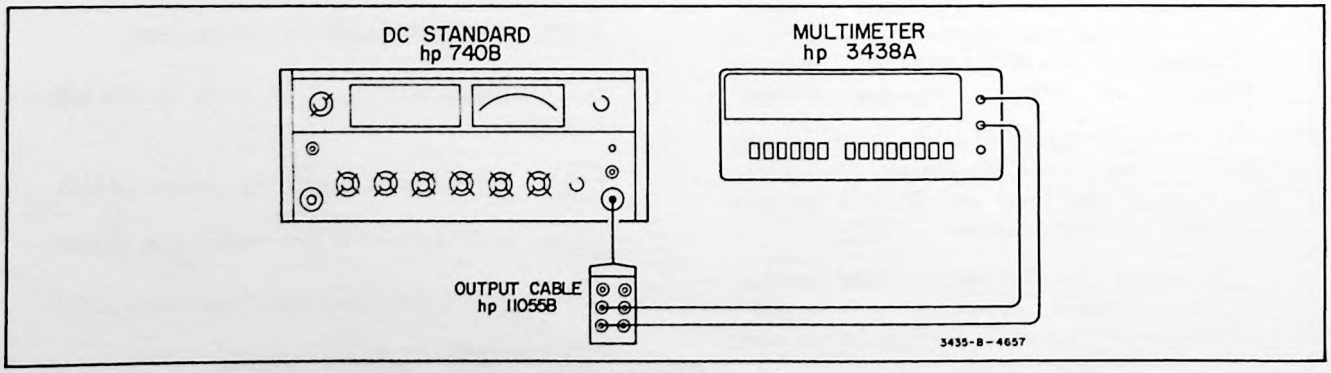


Figure 5-1. DC Gain Adjustment.

5-19. (6) Ohms Gain Adjustment (R119).

a. Set the Multimeter to kΩ, 20 kΩ range.

b. Set the GR 1433H Decade Resistor to 19 kΩ and connect it across the V/Ω to COM terminals.

c. Adjust R119 for a Multimeter display reading of 19.00 kΩ.

5-20. (7) AC Gain Adjustment (R123).

a. Set the Multimeter to ac V, 20 V range.

b. Set the 745A AC Calibrator as follows:

Frequency	200 Hz
Voltage range	100 V
Output voltage	19.0000 V (ac)

c. Connect the 745A to the Multimeter as shown in Figure 5-2.

d. Adjust R123 for a Multimeter display reading of 19.00 V.

5-21. (8) 20 V Range, 20 kHz Adjustment (R102).

a. Set the Multimeter to ac V, 20 V range.

b. Set the 745A AC Calibrator as follows:

Frequency	20 kHz
Voltage range	100 V
Output voltage	19.0000 V (ac)

c. Connect the 745A to the Multimeter as shown in Figure 5-2.

d. Adjust R102 for a Multimeter display reading of 19.00 V.

5-22. (9) 2 V Range, 20 kHz Adjustment (R110).

a. Set the 745A AC Calibrator as follows:

Frequency	20 kHz
Voltage range	10 V
Output voltage	1.90000 V (ac)

b. Set the Multimeter to ac V, 2 V range.

c. Connect the 745A to the Multimeter as shown in Figure 5-2.

d. Adjust R110 for a Multimeter display reading of 1.900 V.

5-23. (10) 20 V ac Range, 100 kHz Adjustment (C109).

a. Set the Multimeter to ac V, 20 V range.

b. Set the 745A AC Calibrator as follows:

Frequency	100 kHz
Voltage range	100 V
Output voltage	19.0000 V (ac)

c. Connect the 745A to the Multimeter as shown in Figure 5-2.

d. Adjust C109 for a Multimeter display reading of 19.00 V.

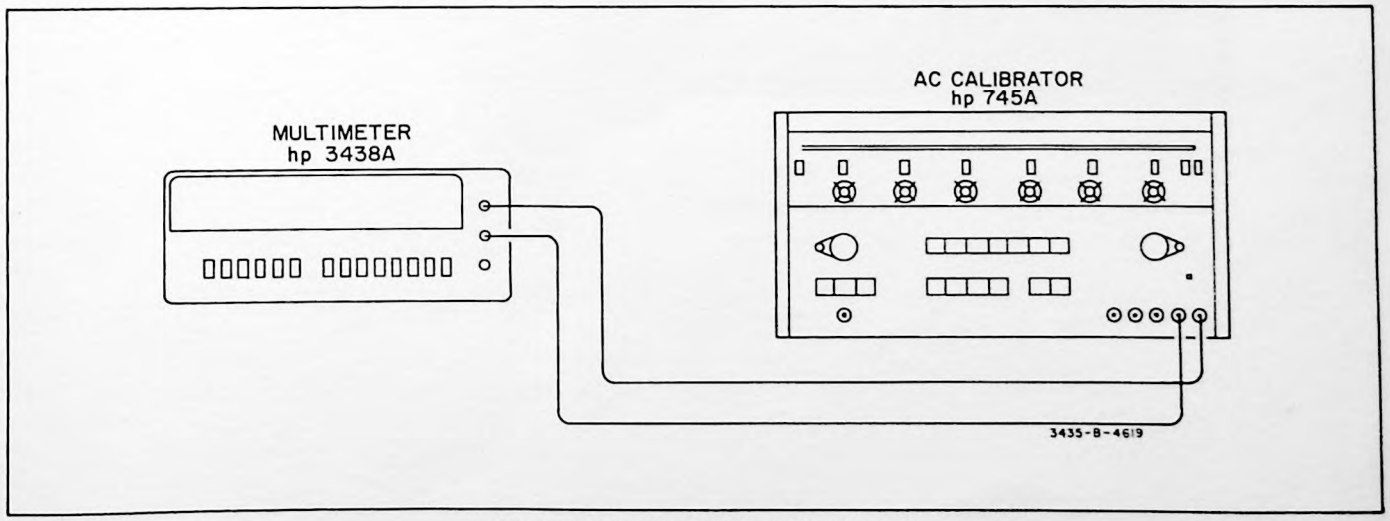


Figure 5-2. AC Gain Adjustment.

5-24. POWER REQUIREMENT MODIFICATION INSTRUCTIONS.

5-25. There are four different line voltage configurations available for the Multimeter. To change line voltage requirements, arrange resistors R421 through R425 to accomodate the desired line voltage as shown in Figure 5-3.

NOTE

A jumper (short) may be substituted for the 2.7 ohm resistors (R421-R425).

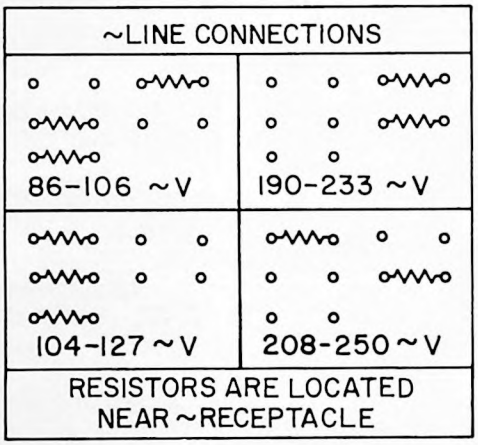


Figure 5-3. Line Voltage Configurations.

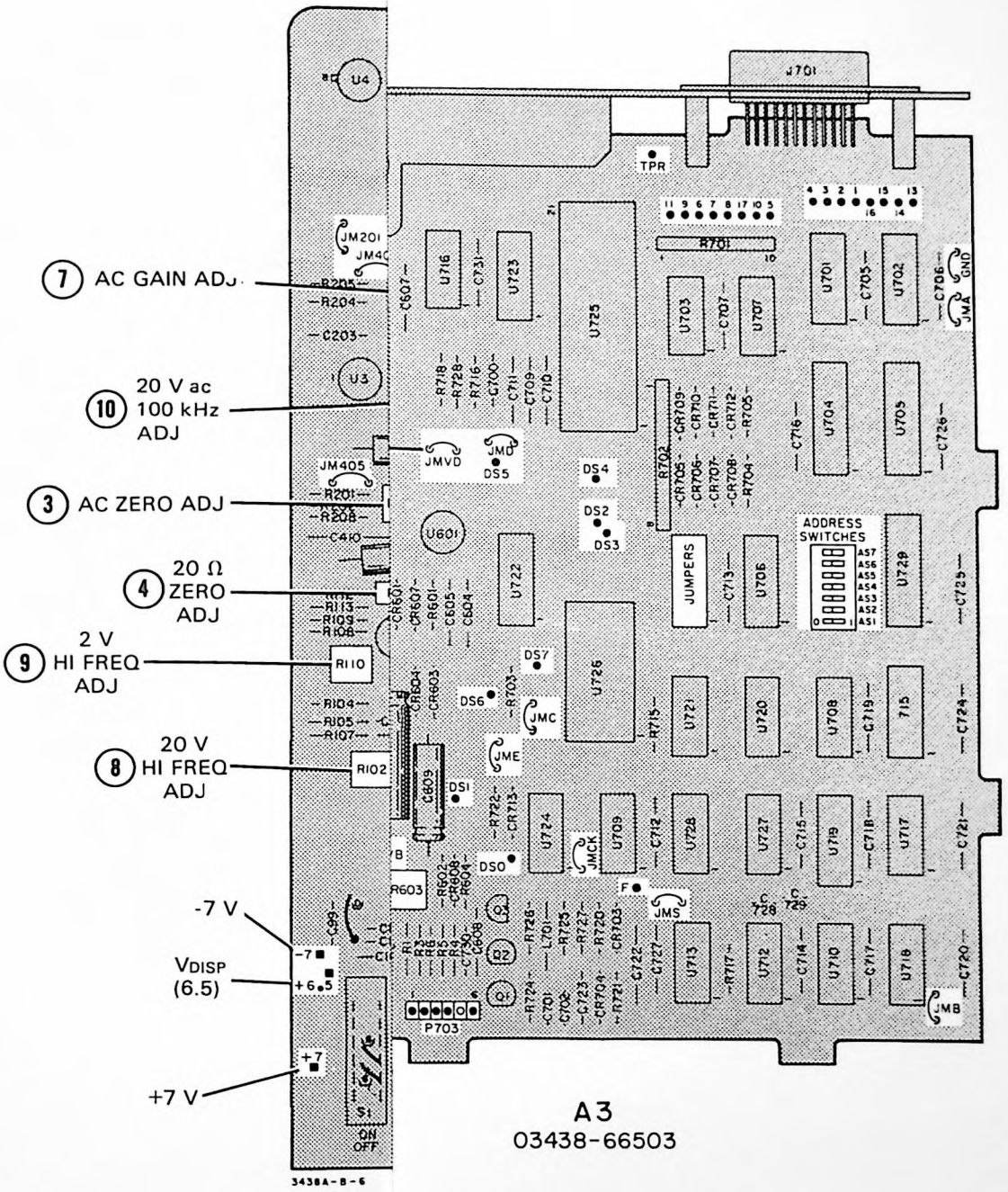
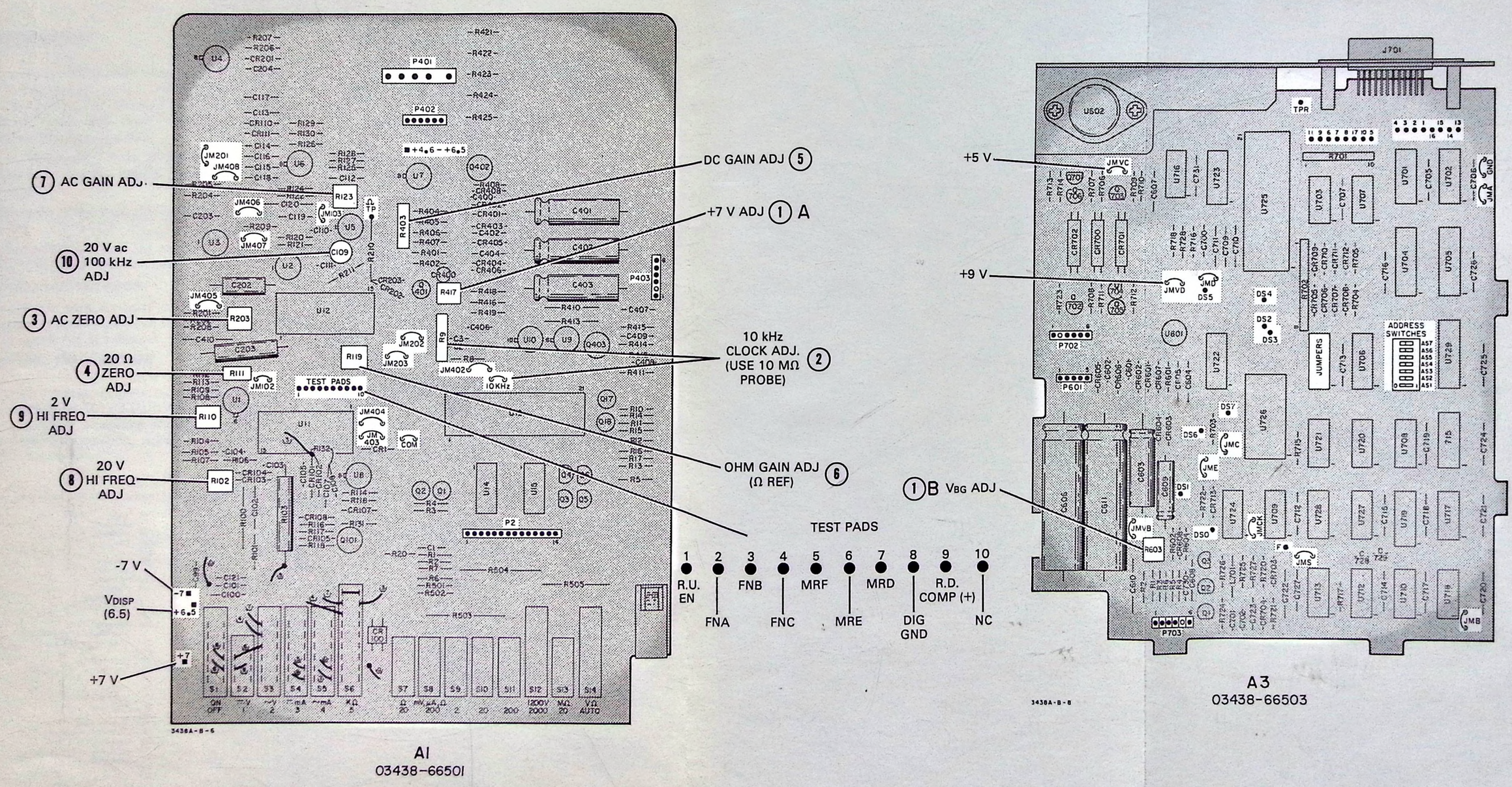


Figure 5-4. Adjustment Locator.



A1
03438-66501

A3
03438-66503

Figure 5-4. Adjustment Locator.

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-3 lists parts in alphameric order of their reference designators and indicates the description, -hp- Part Number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (Qty column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations in Table 6-1.)

c. Typical manufacturer of the part is a five-digit code. (See Table 6-2 for list of manufacturers.)

d. Manufacturer's part number.

6-3. Miscellaneous parts are listed in Table 6-3 following their respective assemblies. General miscellaneous parts are listed at the conclusion of Table 6-3.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix A for list of office locations.) Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.
b. Instrument serial number.
c. Description of the part.
d. Function and location of the part.

6-8. PARTS CHANGES.

6-9. Components which have been changed are so marked by one of three symbols; i.e., Δ, Δ with a letter subscript, e.g., Δ_a, or Δ with a number subscript, e.g., Δ_{10}. A Δ with no subscript indicates the component listed is the preferred replacement for an earlier component. A Δ with a letter subscript indicates a change which is explained in a note at the bottom of the page. A Δ with a number subscript indicates the related change is discussed in backdating (Section VIII). The number of the subscript indicates the number of the change in backdating which should be referred to.

6-10. PROPRIETARY PARTS.

6-11. Items marked by a dagger (†) in the reference designator column are available only for repair and service of Hewlett-Packard instruments.

Table 6-1. Standard Abbreviations.

ABBREVIATIONS

Ag	silver	Hz	hertz (cycle(s) per second)	NPO	negative positive zero (zero temperature coefficient)	sl	slide
Al	aluminum	ID	inside diameter	ns	nanosecond(s) = 10^{-9} seconds	SPDT	single pole double throw
A	ampere(s)	impg	impregnated	nsr	not separately replaceable	SPST	single pole single throw
Au	gold	incd	incandescent			Ta	tantalum
C	capacitor	ins	insulation(ed)	Ω	ohm(s)	TC	temperature coefficient
cer	ceramic			obd	order by description	TiO_2	titanium dioxide
coef	coefficient	kΩ	kilohm(s) = 10^{+3} ohms	OD	outside diameter	tog	toggle
com	common	kHz	kilohertz = 10^{+3} hertz			tol	tolerance
comp	composition			p	peak	trim	trimmer
conn	connection	L	inductor	pA	picoampere(s)	TSTR	transistor
		lin	linear taper	pc	printed circuit		
dep	deposited	log	logarithmic taper	pF	picofarad(s) 10^{-12} farads	V	volt(s)
DPDT	double-pole double-throw			piv	peak inverse voltage	vacw	alternating current working voltage
DPST	double-pole single-throw	mA	milliampere(s) = 10^{-3} amperes	p/o	part of	var	variable
		MHz	megahertz = 10^{+6} hertz	pos	position(s)	vdcw	direct current working voltage
elect	electrolytic	MΩ	megohm(s) = 10^{+6} ohms	poly	polystyrene		
encap	encapsulated	met flm	metal film	pot	potentiometer	W	watt(s)
		mfr	manufacturer	p-p	peak to peak	w/	with
F	farad(s)	ms	millisecond	ppm	parts per million	wiv	working inverse voltage
FET	field effect transistor	mtg	mounting	prec	precision (temperature coeffient, long term stability and/or tolerance)	w/o	without
fxd	fixed	mV	millivolt(s) = 10^{-3} volts			ww	wirewound
		μF	microfarad(s)				
GaAs	gallium arsenide	μs	microsecond(s)	R	resistor		
GHz	gigahertz = 10^{+9} hertz	μV	microvolt(s) = 10^{-6} volts	Rh	rhodium	*	optimum value selected at factory, average value shown (part may be omitted)
gd	guard(ed)	my	Mylar®	rms	root-mean-square	**	no standard type number assigned selected or special type
Ge	germanium			rot	rotary		
gnd	ground(ed)	nA	nanoampere(s) = 10^{-9} amperes				
		NC	normally closed	Se	selenium		® Dupont de Nemours
H	henry(ies)	Ne	neon	sect	section(s)		
Hg	mercury	NO	normally open	Si	silicon		

DESIGNATORS

A	assembly	FL	filter	Q	transistor	TS	terminal strip
B	motor	HR	heater	QCR	transistor-diode	U	microcircuit
BT	battery	IC	integrated circuit	R	resistor	V	vacuum tube, neon bulb,photocell, etc
C	capacitor	J	jack	RT	thermistor	W	cable
CR	diode	K	relay	S	switch	X	socket
DL	delay line	L	inductor	T	transformer	XDS	lampholder
DS	lamp	M	meter	TB	terminal board	XF	fuseholder
E	misc electronic part	MP	mechanical part	TC	thermocouple	Y	crystal
F	fuse	P	plug	TP	test point	Z	network

Table 6-2. Code List of Manufacturers.

Mfr. No.	Manufacturer Name	Address
0000J	Invalid Supplier Code	
0107D	Holsworthy Electronics LTD	Holsworthy Engl, ND
0160G	Allen-Bradley Co	Milwaukee, WI
0169H	Texas Instr. Inc. Semicond. Cmpnt. Div.	Dallas, TX
0185D	RCL Electronics Inc	Manchester, NH
03888	KDI Pyrofilm Corp.	Whippany, NJ
0203G	Motorola Semiconductor Products	Phoenix, AZ
0217B	Airco Speer Elek Div Air Rdcn Co	Nogales, AZ
0223G	Fairchild Semiconductor Div	Mountain View, CA
0236F	Airco Electronics	Bradford, PA
0248D	CTS Keene Inc	Paso Robles, CA
0271C	General Instr Corp Semicond Prod Gp	Wicksville, NY
16428	Belden Corp	Richmond, IN
0291J	Signetics Corp	Sunnyvale, CA
0299E	Mepco/Electra Corp	Mineral Wells, TX
0329B	Corning Glass Works (Bradford)	Bradford, PA
0340F	National Semiconductor Corp	Santa Clara, CA
28480	HP Div 00 Corporate	Palo Alto, CA
0379D	Advanced Micro Devices Inc	Sunnyvale, CA
0420J	Sprague Electric Co	North Adams, MA
72136	Electro Motive Corp Sub IEC	Willimantic, CT
73138	Beckman Instruments Inc Helipot Div	Fullerton, CA
74970	Johnson E F Co	Waseca, MN
0552D	Dale Electronics Inc	Columbus, NE
0576I	Sealectro Corp	Mamaroneck, NY

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	03438-66511		PC ASSEMBLY, MAIN	28480	03438-66511
A1C1	0150-0012	4	CAPACITOR-FXD .01UF +-20% 1KVDC CER	0420J	C023A102J103M838
A1C2	0160-2384	1	CAPACITOR-FXD 120PF +-5% 500VDC	28480	0160-2384
A1C3	0160-0378	1	CAPACITOR-FXD 27PF +-5% 500VDC	28480	0160-0378
A1C99	0150-0014	1	CAPACITOR-FXD 5000PF +100-0% 500VDC CER	28480	0150-0014
A1C100	0150-0012		CAPACITOR-FXD .01UF +-20% 1KVDC CER	0420J	C023A102J103M838
A1C101	0150-0012		CAPACITOR-FXD .01UF +-20% 1KVDC CER	0420J	C023A102J103M838
A1C102	0160-4418	1	CAPACITOR-FXD 22PF +-5% 500VDC+125+-40	28480	0160-4418
A1C103	0160-0336		CAPACITOR-FXD 100PF +-1% 300VDC MICA0+70	28480	0160-0336
A1C104*	0140-0234	1	CAPACITOR-FXD 500PF +-1% 300VDC MICA0+70	72136	DM15F501F0300MV1C
A1C105*	0160-0336	2	CAPACITOR-FXD 100PF +-1% 300VDC MICA0+70	28480	0160-0336
A1C106	0160-2197	2	CAPACITOR-FXD 10PF +-5% 300VDC	28480	0160-2197
A1C107	0160-0153	1	CAPACITOR-FXD 1000PF +-10% 200VDC POLYE	0420J	292P10292
A1C108	0160-3847	8	CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A1C109	0121-0451	1	CAPACITOR-V TRMR-AIR 1.7-11PF 250V	74970	187-0104-005
A1C110	0160-2197		CAPACITOR-FXD 10PF +-5% 300VDC	28480	0160-2197
A1C111	0140-0145	1	CAPACITOR-FXD 22PF +-5% 500VDC	72136	DM15C220J0500MV1CR
A1C112	0180-0309	2	CAPACITOR-FXD 4.7UF+-20% 35VDC TA	04200	150D475X10A2
A1C113	0180-0309		CAPACITOR-FXD 4.7UF+-20% 35VDC TA	04200	150D475X10A2
A1C114	0180-0291	20	CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A1C115	0150-0044	4	CAPACITOR-FXD 5.6PF +-5% 500VDC TI DIOX	0236F	TYPE JM
A1C116	0150-0044		CAPACITOR-FXD 5.6PF +-5% 500VDC TI DIOX	0236F	TYPE JM
A1C117	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A1C118	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A1C119	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A1C120	0180-0116	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	0420J	150D685X9035B2
A1C121	0150-0012		CAPACITOR-FXD .01UF +-20% 1KVDC CER	0420J	C023A102J103M838
A1C202	0160-0168	1	CAPACITOR-FXD .1UF +-10% 200VDC POLYE	0420J	292P10492
A1C203	0150-0044		CAPACITOR-FXD 5.6PF +-5% 500VDC TI DIOX	0236F	TYPE JM
A1C204	0150-0044		CAPACITOR-FXD 5.6PF +-5% 500VDC TI DIOX	0236F	TYPE JM
A1C205	0170-0038	1	CAPACITOR-FXD .22UF +-10% 200VDC POLYE	28480	0170-0038
A1C400	0160-2055	1	CAPACITOR-FXD .01UF +80-20% 100VDC CER	28480	0160-2055
A1C401	0180-2651	1	CAPACITOR-FXD 470UF+75-10% 16VDC AL	0420J	500D447H016DF7
A1C402	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A1C403	0180-2638	3	CAPACITOR-FXD 220UF+75-10% 35VDC AL	0420J	500D227H035DF7
A1C404	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A1C405	0180-2638		CAPACITOR-FXD 220UF+75-10% 35VDC AL	0420J	500D227H035DF7
A1C406	0140-0198	1	CAPACITOR-FXD 200PF +-5% 300VDC MICA	72136	DM15F201J0300MV1CR
A1C407	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A1C408	0160-0362	1	CAPACITOR-FXD 510PF +-5% 300VDC MICA0+70	28480	0160-0362
A1C409	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A1C410	0180-0228	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	0420J	150D226X9015B2
A1CR1	1901-0040	19	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR100	1906-0096	1	DIODE-FW BRDG 200V 1.8A	28480	1906-0096
A1CR101	1901-0376	2	DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
A1CR102	1901-0376		DIODE-GEN PRP 35V 50MA DO-7	28480	1901-0376
A1CR103	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR104	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR105	1901-0029	13	DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
A1CR107	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR108	1902-0554	1	DIODE-ZNR 10V 5% DO-15 PD=1W TC=+.06%	28480	1902-0554
A1CR110	1901-0535	2	DIODE-SCHOTTKY	28480	1901-0535
A1CR111	1901-0535		DIODE-SCHOTTKY	28480	1901-0535
A1CR200	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR201	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR202	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR203	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1CR400	1902-1329	1	DIODE-ZNR 6.95V	28480	1902-1329
A1CR401	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
A1CR402	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
A1CR403	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
A1CR407,408	1901-0050	2	DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
A1CR404	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
A1CR405	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
A1CR406	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MPG9A
	1901-0050		DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
A1J2	03438-61601		14 PIN FEMALE CONNECTOR; P/O W3	28480	03438-61601
A1J401	9100-4011		5 PIN FEMALE CONNECTOR; P/O T1	28480	9100-4011
A1J402	9100-4011		6 PIN FEMALE CONNECTOR; P/O T1	28480	9100-4011
A1J403	03438-61604		6 PIN FEMALE CONNECTOR; P/O W2 PIN 2 BLANK	28480	03438-61604
A1P2	1251-5064		14 PIN MALE CONNECTOR (DISPLAY)	28480	1251-5064
A1P401	1251-4958		5 PIN MALE CONNECTOR (T1 PRIMARY)	28480	1251-4958
A1P402	1251-4624		6 PIN MALE CONNECTOR (T1 SECONDARY)	28480	1251-4624
A1P403	1251-5063		6 PIN MALE CONNECTOR (I/O) PIN 2 CLIPPED	28480	1251-5063

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1Q1	1854-0071	14	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q2	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q3	1853-0016	4	TRANSISTOR PNP SI TO-92 PD=300MW	28480	1853-0016
A1Q4	1853-0016		TRANSISTOR PNP SI TO-92 PD=300MW	28480	1853-0016
A1Q5	1853-0016		TRANSISTOR PNP SI TO-92 PD=300MW	28480	1853-0016
A1Q6	1853-0016		TRANSISTOR PNP SI TO-92 PD=300MW	28480	1853-0016
A1Q17	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q18	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q101	1854-0079	1	TRANSISTOR NPN 2N3439 SI TO-5 PD=1W	02035	2N3439
A1Q401	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1Q402	1854-0039	1	TRANSISTOR NPN 2N30538 SI TO-39 PD=1W	02035	2N3053
A1Q403	1853-0012	1	TRANSISTOR PNP 2N2904A SI TO-39 PD=600MW	01696	2N2904A
A1R1	0698-8767	3	RESISTOR 200K 5% .25W CC TC=-800/+900	01607	CB2045
A1R2	0698-8767		RESISTOR 200K 5% .25W CC TC=-800/+900	01607	CB2045
A1R3	0683-4735	2	RESISTOR 47K 5% .25W FC TC=-400/+800	01607	CB4735
A1R4	0683-4735		RESISTOR 47K 5% .25W FC TC=-400/+800	01607	CB4735
A1R5	0683-1025	8	RESISTOR 1K 5% .25W FC TC=-400/+600	01607	CB1025
A1R6	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01607	CB1025
A1R7	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01607	CB1025
A1R8	0698-4519	1	RESISTOR 140K 1% .125W F TC=0+-100	03297	C4-1/8-T0-1403-F
A1R9	2100-3094	1	RESISTOR-TRMR 100K 10% C SIDE-ADJ 17-TRN	73138	89PR100K
A1R10	0683-5115	4	RESISTOR 510 5% .25W FC TC=-400/+600	01607	CB5115
A1R11	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01607	CB5115
A1R12	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01607	CB5115
A1R13	0683-5115		RESISTOR 510 5% .25W FC TC=-400/+600	01607	CB5115
A1R14	0683-2035	7	RESISTOR 20K 5% .25W FC TC=-400/+800	01607	CB2035
A1R15	0683-2035		RESISTOR 20K 5% .25W FC TC=-400/+800	01607	CB2035
A1R16	0683-2035		RESISTOR 20K 5% .25W FC TC=-400/+800	01607	CB2035
A1R17	0683-2035		RESISTOR 20K 5% .25W FC TC=-400/+800	01607	CB2035
A1R20	0757-0437	4	RESISTOR 4.75K 1% .125W F TC=0+-100	03297	C4-1/8-T0-4751-F
A1R100	0698-8717	1	RESISTOR 4.78M 1% 1W F TC=0+-50	03888	PME708
A1R101	0757-0437		RESISTOR 4.75K 1% .125W F TC=0+-100	03297	C4-1/8-T0-4751-F
A1R102	2100-0558	1	RESISTOR-TRMR 20K 10% C TOP-ADJ 1-TRN	73138	72-109-0
A1R103	0698-8716	1	RESISTOR 8M .5% 2W F TC=0+-50	03888	PME758
A1R106	0683-1065	1	RESISTOR 10M 5% .25W FC TC=-900/+1100	01607	CB1065
A1R107	0683-0275	6	RESISTOR 2.7 5% .25W FC TC=-400/+500	01607	CB27G5
A1R108	0698-4123	2	RESISTOR 499 1% .125W F TC=0+-100	03297	C4-1/8-T0-499R-F
A1R109	0698-4202	1	RESISTOR 8.87K 1% .125W F TC=0+-100	03297	C4-1/8-T0-8871-F
A1R110	2100-3211	2	RESISTOR-TRMR 1K 10% C TOP-ADJ 1-TRN	73138	72-105-0
A1R111	2100-3366	1	RESISTOR-TRMR 100K 10% C TOP-ADJ 18-TRN	73138	68WR100K
A1R112	0757-0472	3	RESISTOR 200K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2003-F
R113	0757-0410	2	RESISTOR 301 1% .125W F TC=0+-100	03297	C4-1/8-T0-301R-F
R114	0757-0473	2	RESISTOR 221K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2213-F
R115	0698-3159	2	RESISTOR 26.1K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2612-F
R116	0698-8767		RESISTOR 200K 5% .25W CC TC=-800/+900	01607	CB2045
R117	0757-0437		RESISTOR 4.75K 1% .125W F TC=0+-100	03297	C4-1/8-T0-4751-F
R118	0698-8768	3	RESISTOR 100 5% .25W CC TC=-400/+500	01607	CB1015
A1R119	2100-3210	3	RESISTOR-TRMR 10K 10% C TOP-ADJ 1-TRN	73138	72-108-0
A1R120	0698-4485	1	RESISTOR 23.2K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2322-F
A1R121	0757-0449	6	RESISTOR 20K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2002-F
A1R122	0698-3160	1	RESISTOR 31.6K 1% .125W F TC=0+-100	03297	C4-1/8-T0-3162-F
A1R123	2100-3211		RESISTOR-TRMR 1K 10% C TOP-ADJ 1-TRN	73138	72-105-0
A1R124	0698-4479	1	RESISTOR 14K 1% .125W F TC=0+-100	03297	C4-1/8-T0-1402-F
A1R125	0757-0473		RESISTOR 221K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2213-F
A1R126	0683-1055	1	RESISTOR 1M 5% .25W FC TC=-800/+900	01607	CB1055
A1R127	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2002-F
A1R128	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2002-F
A1R129	0757-0283	5	RESISTOR 2K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2001-F
A1R130	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2001-F
A1R131	0698-8768		RESISTOR 100 5% .25W CC TC=-400/+500	01607	CB1015
A1R132	0757-0442	1	RESISTOR 10K 1% .125W F TC=0+-100	03297	C4-1/8-T0-1002-F
A1R201	0757-0410		RESISTOR 301 1% .125W F TC=0+-100	03297	C4-1/8-T0-301R-F
A1R202	0757-0472	1	RESISTOR 200K 1% .125W F TC=0+-100	03292	C4-1/8-T0-2003-F
A1R203	2100-3214	1	RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN	73138	72-112-0
A1R204	0698-4123		RESISTOR 499 1% .125W F TC=0+-100	03297	C4-1/8-T0-499R-F
A1R205	0757-0472		RESISTOR 200K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2003-F
A1R206	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01607	CB1025
A1R207	0757-0472		RESISTOR 200K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2003-F
A1R208	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2002-F
A1R209	0757-0270	1	RESISTOR 249K 1% .125W F TC=0+-100	03297	C4-1/8-T0-2493-F
A1R210	0698-8769	1	RESISTOR 49.7K .1% .5W F TC=0+-50	01070	H2
A1R211	0698-8396	1	RESISTOR 500K .1% .25W F TC=0+-50	0299E	MF52C1/4-T2-5003-B
A1R401	0698-4472	1	RESISTOR 7.68K 1% .125W F TC=0+-100	03297	C4-1/8-T0-7681-F
A1R402	0698-6481	1	RESISTOR 16.2K 1% .125W F TC=0+-25	03297	NE55
A1R403	2100-3056	1	RESISTOR-TRMR 5K 10% C SIDE-ADJ 17-TRN	73138	89PR5K
A1R404	0698-7646	1	RESISTOR 31.6K 1% .125W F TC=0+-25	0299E	MFQC1/8-T9-3162-F
A1R405	0698-3540	1	RESISTOR 15.4K 1% .125W F TC=0+-100	03297	C4-1/8-T0-1542-F

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1R406	0757-0459	1	RESISTOR 56.2K 1% .125W F TC=0+-100	03298	C4-1/8-T0-5622-F
A1R407	0698-3159		RESISTOR 26.1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2612-F
A1R408	0698-8768		RESISTOR 100 5% .25W CC TC=-400/+500	01606	CB1015
A1R410	0698-3332	1	RESISTOR 80.6 1% .5W F TC=0+-100	05520	CMF-65-2
A1R411	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2002-F
A1R412	0757-0449		RESISTOR 20K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2002-F
A1R413	0698-4842	1	RESISTOR 124 1% .5W F TC=0+-100	05520	CMF-65-2
A1R414	0757-0437		RESISTOR 4.75K 1% .125W F TC=0+-100	03298	C4-1/8-T0-4751-F
A1R415	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	03298	C4-1/8-T0-2001-F
A1R416	0757-0458	1	RESISTOR 51.1K 1% .125W F TC=0+-100	03298	C4-1/8-T0-5112-F
A1R417	2100-3210		RESISTOR-TRMR 10K 10% C TOP-ADJ 1-TRN	73138	72-108-0
A1R418	0698-4502	1	RESISTOR 64.9K 1% .125W F TC=0+-100	03298	C4-1/8-T0-6492-F
A1R419	0698-3279	1	RESISTOR 4.99K 1% .125W F TC=0+-100	03298	C4-1/8-T0-4991-F
A1R421	0683-0275		RESISTOR 2.7 5% .25W FC TC=-400/+500	01606	CB2705
A1R422	0683-0275		RESISTOR 2.7 5% .25W FC TC=-400/+500	01606	CB2705
A1R423	0683-0275		RESISTOR 2.7 5% .25W FC TC=-400/+500	01606	CB2705
A1R424	0683-0275		RESISTOR 2.7 5% .25W FC TC=-400/+500	01606	CB2705
A1R425	0683-0275		RESISTOR 2.7 5% .25W FC TC=-400/+500	01606	CB2705
A1R501	0698-5453	1	RESISTOR 900 .1% .125W F TC=0+-50	03888	PME55 T-2-900R-B
A1R502	0698-5456	1	RESISTOR 90 .1% .125W F TC=0+-50	03298	NC55
A1R503	0811-3433	1	RESISTOR 9 .1% 3W PW TC=0+-50	0183D	T2R-79
A1R504	0811-3455	1	RESISTOR .9 .1% 4W PW TC=0+-90	0183D	T3
A1R505	0811-3435	1	RESISTOR .1 .1% 3W PW TC=0+-90	0183D	T2R-79
A1S1	3101-2129		PUSHBUTTON SWITCH (PUSH-PUSH)	28480	3101-2129
A1S2	3101-2130		PUSHBUTTON SWITCH	28480	3101-2130
A1S3-S5	3101-2128		PUSHBUTTON SWITCH	28480	3101-2128
A1S6	3101-2127		PUSHBUTTON SWITCH	28480	3101-2127
A1S7-S11	3101-2130		PUSHBUTTON SWITCH	28480	3101-2130
A1S12	3101-2128		PUSHBUTTON SWITCH	28480	3101-2128
A1S13	3101-2130		PUSHBUTTON SWITCH	28480	3101-2130
A1S14	3101-2128		PUSHBUTTON SWITCH	28480	3101-2138
A1S1 THRU S14	03438-61901		COMPLETE SWITCH ASSEMBLY WITH FLYING LEADS ATTACHED	28480	03438-61901
A1U1	1826-0340	1	IC OP AMP	28480	1826-0340
A1U2	1826-0043	4	IC OP AMP	0340F	LM307H
A1U3 - U6	1820-0223	4	IC 301 OP AMP	0379D	LM301A
A1U7 - U9	1826-0043		IC OP AMP	0340F	LM307H
A1U10	1820-0196	1	IC 723 V RGLTR	0223G	723HC
A1U11	1813-0070	1	INPUT HYBRID	28480	1813-0070
A1U12	1813-0071	1	INTEGRATOR HYBRID	28480	1813-0071
A1U13	1820-1742	1	CONTROL CHIP	28480	1820-1742
A1U14	1820-2254	2	IC DRVR TTL LED DRVR HEX	28480	1820-2254
A1U15	1820-2254		IC DRVR TTL LED DRVR HEX	28480	1820-2254
A1W1	03435-61603	1	CABLE -+5 V	28480	03435-61603
			A1 MISCELLANEOUS PARTS		
	0370-2486	7	PUSHBUTTON(SOLID GRAY)	28480	0370-2486
	0370-2625	1	PUSHBUTTON (WHITE)	28480	0370-2625
	0370-2873	5	PUSHBUTTON (DARK GREG)	28480	0370-2873
	0370-2917	1	PUSHBUTTON (LIGHT BLUE)	28480	0370-2917
	0380-0162	1	STANDOFF-RVT-ON .75LG 6-32THD .250D BRS	28480	0380-0162
	1460-1485	1	SPRING (SM WET) .25-IN-W 1.555-IN-LG BE	28480	1460-1485
	1530-1098	4	FASTENER10.136" DIA 6-32 THREAD	0000J	CBD
	2110-0269	2	FUSEHOLDER-CLIP TYPE .25D-FUSE	28480	2110-0269
	5040-8068	1	HOLDER, SPRING	28480	5040-8068
A2	03438-66512		PC ASSEMBLY, DISPLAY	28480	03438-66512
A2DS1	1990-0404	10	LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2DS2	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2DS3	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2DS4	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2DS5	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2D86	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2D87	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2D88	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2D89	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2D810	1990-0404		LED-VISIBLE LUM-INT=300UCD IF=50MA-MAX	28480	1990-0404
A2DSM1	1990-0532	1	DISPLAY-NUM 8EG .5-CHAR .29-H	28480	1990-0532
A2DSM2	1990-0531	3	DISPLAY-NUM 8EG 1-CHAR .3-H GA-ARSD-PPHD	28480	1990-0531
A2DSM3	1990-0531		DISPLAY-NUM 8EG 1-CHAR .3-H GA-ARSD-PPHD	28480	1990-0531
A2DSM4	1990-0531		DISPLAY-NUM 8EG 1-CHAR .3-H GA-ARSD-PPHD	28480	1990-0531
A2J3	03438-61601		14 PIN FEMALE CONNECTOR; P/O W3	28480	03438-61601
A2J4	03438-61602		6 PIN FEMALE CONNECTOR; P/O W5 PIN 5 BLANK	28480	03438-61602
A2J602	03438-61603		2 PIN FEMALE CONNECTOR; P/O W4	28480	03438-61603
A2P3	1251-5064		14 PIN MALE CONNECTOR (DISPLAY)	28480	1251-5064
A2P4	1251-5063		6 PIN MALE CONNECTOR (ANNUNCIATOR) PIN 5 CLIPPED	28480	1251-5063
A2P602	1251-5081		2 PIN MALE CONNECTOR (+5 V SUPPLY)	28480	1251-5081
A2R1, R2	0683-1115	14	RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R3	0683-2215	3	RESISTOR 220 5% .25W VC TC=-400/+600	0160G	CB2215
A2R4 - R7	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R8	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R9	0683-2215		RESISTOR 220 5% .25W FC TC=-400/+600	0160G	CB2215
A2R10	0683-2215		RESISTOR 220 5% .25W FC TC=-400/+600	0160G	CB2215
A2R19	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R20	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R21	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R22	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R23	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R24	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
A2R25	0683-1115		RESISTOR 110 5% .25W FC TC=-400/+600	0160G	CB1115
3	03438-66503		HP-IB BOARD ASSEMBLY	28480	03438-66503
3C601	0160-3622	4	CAPACITOR-FXD .1UF +80-20% 100VDC CER	28480	0160-3622
A3C602	0160-3622		CAPACITOR-FXD .1UF +80-20% 100VDC CER	28480	0160-3622
A3C603	0180-2638		CAPACITOR-FXD 220UF+75-10% 35VDC AL	0420J	500D227M035DF7
A3C604	0180-1735	2	CAPACITOR-FXD .22UF+-10% 35VDC TA	0420J	150D224X9035A2
A3C605	0180-0210	2	CAPACITOR-FXD 3.3UF+-20% 15VDC TA	0420J	150D335X0015A2
A3C606	0180-2100	2	CAPACITOR-FXD 1200UF+75-10% 15VDC AL	0420J	390128G015FL4
A3C607	0180-1735		CAPACITOR-FXD .22UF+-10% 35VDC TA	0420J	150D224X9035A2
A3C608	0180-0210		CAPACITOR-FXD 3.3UF+-20% 15VDC TA	0420J	150D335X0015A2
A3C609	0180-0049	1	CAPACITOR-FXD 20UF+75-10% 50VDC AL	0420J	300206Q050CC2
A3C610	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	0420J	150D226X9015B2
A3C611	0180-2100		CAPACITOR-FXD 1200UF+75-10% 15VDC AL	0420J	390128G015FL4
A3C700	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A3C701	0160-3520	2	CAPACITOR-FXD 75PF +-1% 100VDC	28480	0160-3520
A3C702	0160-3520		CAPACITOR-FXD 75PF +-1% 100VDC	28480	0160-3520
A3C705	0180-1701	4	CAPACITOR-FXD 6.8UF+-20% 6VDC TA	0420J	150D685X0006A2
A3C706	0180-1701		CAPACITOR-FXD 6.8UF+-20% 6VDC TA	0420J	150D685X0006A2
A3C707	0180-1701		CAPACITOR-FXD 6.8UF+-20% 6VDC TA	0420J	150D685X0006A2
A3C709	0180-1701		CAPACITOR-FXD 6.8UF+-20% 6VDC TA	0420J	150D685X0006A2
A3C710	0180-0309	2	CAPACITOR-FXD 4.7UF+-20% 10VDC TA	0420J	150D475X0010A2
A3C711	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C712	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C713	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C714	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C715	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C716	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C717	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C718	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C719	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C720	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C721	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3C722	0180-0229	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	0420J	150D336X9010B2
A3C723	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A3C724	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C725	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C726	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C727	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C728	0160-3622		CAPACITOR-FXD .1UF +80-20% 100VDC CER	28480	0160-3622
A3C729	0160-3622		CAPACITOR-FXD .1UF +80-20% 100VDC CER	28480	0160-3622
A3C730	0160-3847		CAPACITOR-FXD .01UF +100-0% 50VDC CER	28480	0160-3847
A3C731	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	0420J	150D105X9035A2
A3C808	0180-0309	2	CAPACITOR-FXD 4.7UF +-20% 10VDC TA	04200	150D475X0010A2
A3CR601	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MP494
A3CR602	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MP494
A3CR603	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MP494
A3CR604	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MP494
A3CR605	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MP494
A3CR606	1901-0029		DIODE-PWR RECT 600V 750MA DO-29	0271C	MP494
A3CR607	1902-3073	1	DIODE-ZNR 4.32V 5% DO-7 PD=.4W TC=-.049%	02763	CD35601
A3CR608	1902-3104	1	DIODE-ZNR 5.62V 5% DO-7 PD=.4W TC=+.016%	02030	BZ.10939-110
A3CR700	1990-0514	3	OPTO-ISOLATOR LED-PDIO/X8TR IF=1A-MAX	28480	1990-0514
A3CR701	1990-0514		OPTO-ISOLATOR LED-PDIO/X8TR IF=1A-MAX	28480	1990-0514
A3CR702	1990-0514		OPTO-ISOLATOR LED-PDIO/X8TR IF=1A-MAX	28480	1990-0514
A3CR703	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3CR704	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3CR705	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3CR706	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3CR707 - 713	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3J601	9100-4011		5 PIN FEMALE CONNECTOR P/O T1	28480	9100-4011
A3J701	1251-3283		HP-IB CONNECTOR	28480	1251-3283
A3J702	03438-61604		6 PIN FEMALE CONNECTOR P/O W2 PIN 2 BLANK	28480	03438-61604
A3J703	03438-61602		6 PIN FEMALE CONNECTOR P/O W5 PIN 5 BLANK	28480	03438-61602
A3L701	9100-1640		COIL 160 UF 5%	28480	9100-1640
A3P601	1251-4841		5 PIN MALE CONNECTOR (T1 SECONDARY)	28480	1251-4841
A3P702	1251-5063		6 PIN MALE CONNECTOR (I/O) PIN 2 CLIPPED	28480	1251-5063
A3P703	1251-5063		6 PIN MALE CONNECTOR (ANNUNCIATOR) PIN 5 CLIPPED	28480	1251-5063
A3Q1	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q2	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q3	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q701	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q702	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q703	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q704	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q705	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q706	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3R1	0683-2035		RESISTOR 20K 5% .25W FC TC=-400/+800	01606	CB2035
A3R2	0683-4715	3	RESISTOR 470 5% .25W FC TC=-400/+600	01606	CB4715
A3R3	0683-2035		RESISTOR 20K 5% .25W FC TC=-400/+800	01606	CB2035
A3R4	0683-4715		RESISTOR 470 5% .25W FC TC=-400/+600	01606	CB4715
A3R5	0683-2035		RESISTOR 20K 5% .25W FC TC=-400/+800	01606	CB2035
A3R6	0683-4715		RESISTOR 470 5% .25W FC TC=-400/+600	01606	CB4715
A3R601	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+800	01606	CB1025
A3R602	0683-1825	1	RESISTOR 1.8K 5% .25W FC TC=-400/+700	01606	CB1825
A3R603	2100-0567	1	RESISTOR-TRMR 2K 10% C TOP-ADJ 1-TRN	73138	72-106-0
A3R604	0683-8215	1	RESISTOR 820 5% .25W FC TC=-400/+600	01606	CB8215
A3R701	1810-0136	1	NETWORK-RES 10-PIN-SIP .1-PIN-SPCG	28480	1810-0136
A3R702	1810-0055	1	NETWORK-RES 9-PIN-SIP .15-PIN-SPCG	28480	1810-0055
A3R703	0683-1525	1	RESISTOR 1.5K 5% .25W FC TC=-400/+700	01606	CB1525
A3R704	0757-0401	1	RESISTOR 100 1% .125W F TC=0+-100	03298	C4-1/8-T0-101-F
A3R705	0698-4453	1	RESISTOR 402 1% .125W F TC=0+-100	03298	C4-1/8-T0-402R-F
A3R706	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01606	CB1025
A3R707	0757-0161	2	RESISTOR 604 1% .125W F TC=0+-100	03298	C4-1/8-T0-604R-F
A3R708	0698-3178	3	RESISTOR 487 1% .125W F TC=0+-100	03298	C4-1/8-T0-487R-F
A3R709	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01606	CB1025
A3R710	0757-0161		RESISTOR 604 1% .125W F TC=0+-100	03298	C4-1/8-T0-604R-F
A3R711	0698-3178		RESISTOR 487 1% .125W F TC=0+-100	03298	C4-1/8-T0-487R-F
A3R712	0683-1335	1	RESISTOR 13K 5% .25W FC TC=-400/+800	01606	CB1335
A3R713	0683-1135	1	RESISTOR 11K 5% .25W FC TC=-400/+800	01606	CB1135
A3R714	0698-3178		RESISTOR 487 1% .125W F TC=0+-100	03298	C4-1/8-T0-487R-F
A3R715	0683-1035	3	RESISTOR 10K 5% .25W FC TC=-400/+700	01606	CB1035
A3R716	0757-0469	1	RESISTOR 150K 1% .125W F TC=0+-100	03298	C4-1/8-T0-1503-F
A3R717	0683-4725	2	RESISTOR 4.7K 5% .25W FC TC=-400/+700	01606	CB4725
A3R718	0683-4725		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01606	CB4725
A3R720	0698-4442	1	RESISTOR 4.42K 1% .125W F TC=0+-100	03298	C4-1/8-T0-4421-F
A3R721	0683-1025		RESISTOR 1K 5% .25W FC TC=-400/+600	01606	CB1025

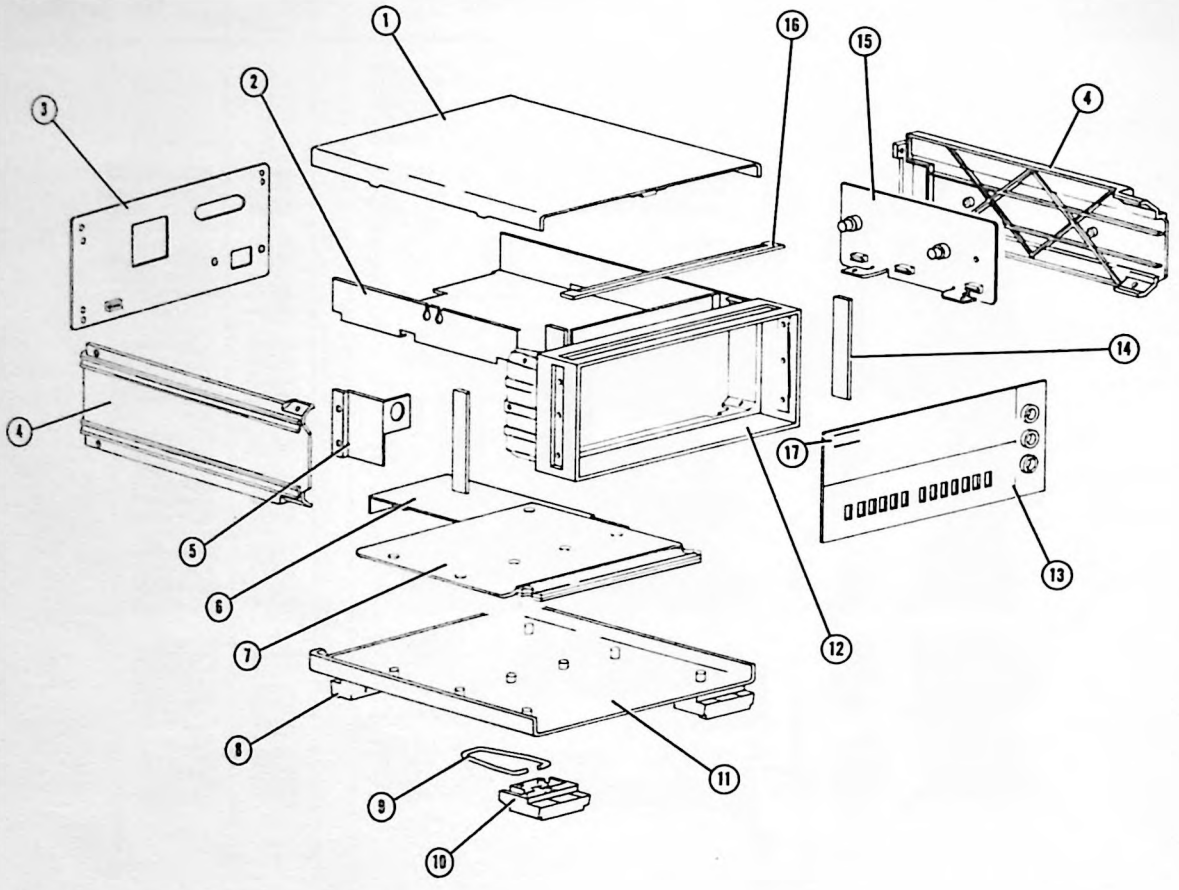
Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3R722	0683-5125		RESISTOR 5100 5% .25W FC TC=-400/+700	0160G	CB5125
A3R723	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	0160G	CB1035
A3R724	0757-0280	2	RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
A3R725	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-1001-F
A3R726	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-2001-F
A3R727	0757-0283		RESISTOR 2K 1% .125W F TC=0+-100	0329B	C4-1/8-T0-2001-F
A3R728	0683-1035		RESISTOR 10K 5% .25W FC TC=-400/+700	0160G	CB1035
AS1-AS7	3101-1973	1	SWITCH ASSY, 7PST (ADDRESS SWITCH)	28480	3101-1973
A3U601	1820-0429	1	IC V RGLTR	0340F	LM309H
A3U602	1820-0430	1	IC 309 V RGLTR	0283G	LM309K
A3U701	1820-1558	2	IC MISC TTL* QUAD	0203G	MC3441P
A3U702	1820-1558		IC MISC TTL* QUAD	0203G	MC3441P
A3U703	1820-1416	1	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	0169H	SN74LS14N
A3U704	1820-1759	2	IC BFR TTL LS NON-INV OCTL	0340F	DM81LS97N
A3U705	1820-1730	1	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	0169H	SN74LS273
A3U706	1820-1491	1	IC BFR TTL LS NON-INV HEX 1-INP	0169H	SN74LS367N
A3U707	1820-0621	1	IC BFR TTL NAND QUAD 2-INP	0283G	7438PC
A3U708	1820-1200	2	IC INV TTL LS HEX 1-INP	0169H	SN74LS05N
A3U709	1820-1199	2	IC INV TTL LS HEX 1-INP	0169H	SN74LS04N
A3U710	1820-1197	1	IC GATE TTL LS NAND QUAD 2-INP	0169H	SN74LS00N
A3U712	1820-1112	3	IC FF TTL LS D-TYPE POS-EDGE-TRIG	0169H	SN74LS74N
A3U713	1820-1208	1	IC GATE TTL LS OR QUAD 2-INP	0291J	74LS32A
A3U715	1820-1196	2	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	0379D	AM74LS174N
A3U716	1820-1112		IC FF TTL LS D-TYPE POS-EDGE-TRIG	0169H	SN74LS74N
A3U717	1820-1144	1	IC GATE TTL LS NOR QUAD 2-INP	0283G	9LS02PC
A3U718	1820-1206	1	IC GATE TTL LS NOR TPL 3-INP	0169H	SN74LS27N
A3U719	1820-1196		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	0379D	AM74LS174N
A3U720	1820-1198	2	IC GATE TTL LS NAND QUAD 2-INP	0169H	SN74LS03N
A3U721	1820-1198		IC GATE TTL LS NAND QUAD 2-INP	0169H	SN74LS03N
A3U722	1820-1216	1	IC DCDR TTL LS 3-TO-8-LINE 3-INP	0379D	SN74LS138N
A3U723	1820-1423	1	IC MV TTL LS MONOSTBL RETRIG DUAL	0169H	SN74LS123N
A3U724	1820-1199		IC INV TTL LS HEX 1-INP	0169H	SN74LS04N
A3U725	1820-1691	1	IC MICPROC MOB	28480	1820-1691
A3U726	1818-0373	1	ROM 16K MK3400	28480	1818-0373
A3U727	1820-1200		IC INV TTL LS HEX 1-INP	0169H	SN74LS05N
A3U728	1820-1112		IC FF TTL LS D-TYPE POS-EDGE-TRIG	0169H	SN74LS74N
A3U729	1820-1759		IC BFR TTL LS NON-INV OCTL	0340F	DM81LS97N
			A3 MISCELLANEOUS PARTS		
	1200-0473	1	SOCKET-IC 16-CONT DIP-SLDR (USED W/JUMPERS)	28480	1200-0473
	1205-0033	1	HEAT SINK TO-5/TO-39-PKG (U601)	28480	1205-0033
	1810-0307	1	NETWORK SHORTING (JUMPERS)	28480	1810-0307
				28480	03438-26503

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			MISCELLANEOUS PARTS		
	4040-1278	1	SPACER/COUPLER (USED WITH S15)	28480	4040-1278
	03438-00202	1	PANEL, REAR	28480	03438-00202
	03438-00601	1	SHIELD, PC	28480	03438-00601
	03438-00602	1	BRACKET, SWITCH	28480	03438-00602
	03438-00603	1	SHIELD, PC	28480	03438-00603
	03438-00604	1	BRACKET, CONNECTOR	28480	03438-00604
	03438-00605	1	BRACKET, TRANSFORMER	28480	03438-00605
	03438-00606	2	BRACKET, SIDE	28480	03438-00606
	03438-24701	1	SPACER	28480	03438-24701
	03438-66501	1	PC ASSY, MAIN	28480	03438-66501
	03438-66502	1	PC ASSY, DISPLAY	28480	03438-66502
	03438-66503	1	HP-IB BOARD	28480	03438-66503
	03438-90000	1	OPERATING & SERVICE MANUAL	28480	03438-90000
	0380-0644	2	STANDOFF-HEX 6/32"	0000J	08D
	1460-1345	1	TILT STAND SST	28480	1460-1345
	5001-0438	2	TRIM STRIP	28480	5001-0438
	5020-8813	1	FRONT FRAME	28480	5020-8813
	5040-7201	2	FOOT(STANDARD)	28480	5040-7201
	5040-7203	1	TRIM:TOP 1/2	28480	5040-7203
	5040-7208	1	COVER:TOP	28480	5040-7208
	5040-7209	1	COVER:BOTTOM	28480	5040-7209
	5040-7222	2	FOOT-NON-SKID	28480	5040-7222
	5040-7853	4	WASHER	28480	5040-7853
	5040-8210	2	COVER, SIDE	28480	5040-8210
	7120-3930	1	LABEL, CAUTION	28480	7120-3930
	7120-6188	1	NAMEPLATE	28480	7120-6188
	7120-6485	1	LABEL, INFO	28480	7120-6485
	8120-1348	1	CABLE ASSY AC POWER	16428	XMB-7041
		1		28480	8120-2821
	9211-1220	1	CARTON, CORRUGATED	28480	9211-1220

Table 6-4. Miscellaneous Parts



Index No.	-hp- Part No.	Description	Qty
1	5040-7208	Cover: Top	1
2	03438-00601	Shield, PC	1
3	03438-00202	Panel, Rear	1
4	5040-8210	Cover, Side	2
5	03438-00602	Bracket, Switch	1
6	03438-00603	Shield, PC	1
7	03435-00603	Shield, Bottom	1
8	5040-7222	Foot, Non-Skid	2
9	1460-1345	Tilt Stand SST	2
10	5040-7201	Foot, Standard	2
11	5040-7209	Cover: Bottom	1
12	5020-8813	Frame, Front	1
13	03438-00201	Panel, Front	1
14	5001-0438	Trim, Side	2
15	03438-00606	Bracket, Side	2
16	5040-7203	Trim, Top	1
17	7120-6188	-hp- Logo	1

Direct Mail Order Program.

Domestic orders for replacement parts and supplied can be placed through our direct mail order program for U.S. customers. There is no minimum order size. In most cases, your order is shipped the same day it is received at out distribution center, prepaid, where over 70,000 parts are in stock.

To place a mail order, send your check or money order--no cash--to Hewlett-Packard Mail Order Department, P.O. Drawer #20, Mountain View, California 94043. Payment, made payable to Hewlett-Packard, must include local sales tax, if applicable, and $1.50 for handling charges.

Please include in your order the following information:

- Product Number
- Description
- Model number and description of the equipment with which the product is used.
- Unit price of each product.
- Your name, Company's name, full return address, and any special instructions.
- If tax exempt, include your state exemption number.

If we can be of any assistance in placing a mail order or answering inquiries on mail orders, do not hesitate to contact us at:

(415) 968-9200 extention 341, 342

HEWLETT hp PACKARD

CUSTOMER SERVICE CENTER

Direct Mail

Parts and Supplies Order Form

SHIP TO:

COMPANY _____

NAME _____ CUSTOMER REFERENCE # _____

STREET _____ TAXABLE* _____

CITY _____ STATE _____ ZIP CODE _____

Please call the nearest HP Sales Office listed on the back of this form if you need assistance in placing your order.

Item No.	Check Digit	Part No.	Qty.	Description	List Price Each		Extended Total	

Special Instructions	Sub-Total		
	Your State & Local Sales Taxes*		
	Handling Charge	1	50
	TOTAL		

*Hewlett-Packard is registered and licensed to do business in your state, and we are required by the laws of your state to pay state and local taxes to them monthly on all shipments we make into your state. Therefore, we must pass these costs on to the consumer. Tax is verified by computer according to your ZIP CODE. If no sales tax is added, your state exemption number must be provided: # _____. If not, your order may have to be returned.

Check or Money Order, made payable to Hewlett-Packard Company, must accompany order.

When completed, please mail this form with payment to:

HEWLETT-PACKARD COMPANY
Mail Order Department
P.O. Drawer #20
Mountain View, CA 94043

Phone: (415) 968-9200

Most orders are shipped within 24 hours of receipt. Shipments are made via UPS or Air Parcel Post. APO's, FPO's, PO Boxes, or destinations outside the continental 48 States will be shipped Air Parcel Post. Shipments over 25 pounds will be made via truck. No Direct Mail Order can be shipped outside the U.S.

SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION.

7-2. This section of the manual normally contains information necessary to adapt this manual to instruments for which the content does not directly apply. Since, at this printing, the manual does apply directly to instruments having serial numbers listed on the title page, no change information is given here.

MANUAL CHANGES

-hp- MODEL 3438A

DIGITAL MULTIMETER

Manual Part Number 03438-90002

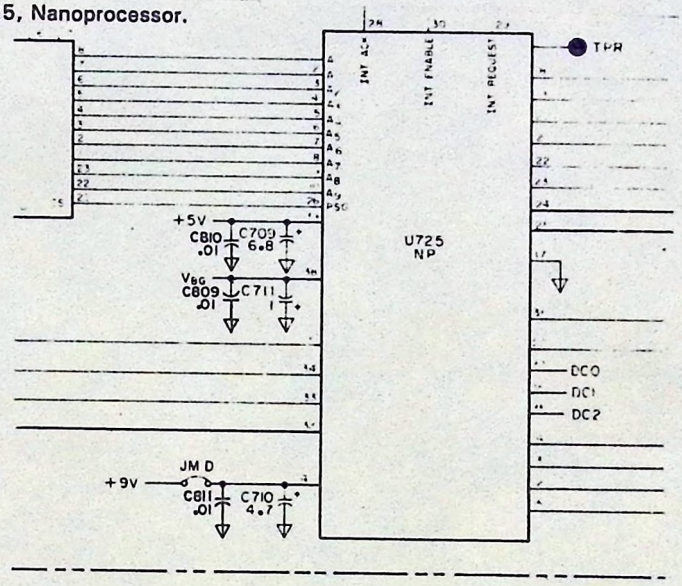
► New or Revised Item

CHANGE NO. 1 for Serial Numbers 1717A02831 or greater.

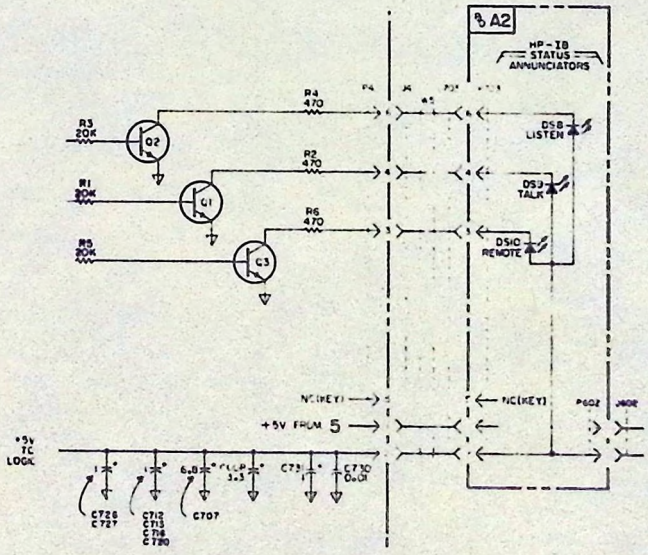
The A3, HP-IB Board has changed from 03498-66503 to 03438-66506.

Page 8-21/8-22, Figure 8-15. HP-IB Schematic. The following two schematic changes have occurred:

Additional Capacitors for U725, Nanoprocessor.



Power Supply Filtering.



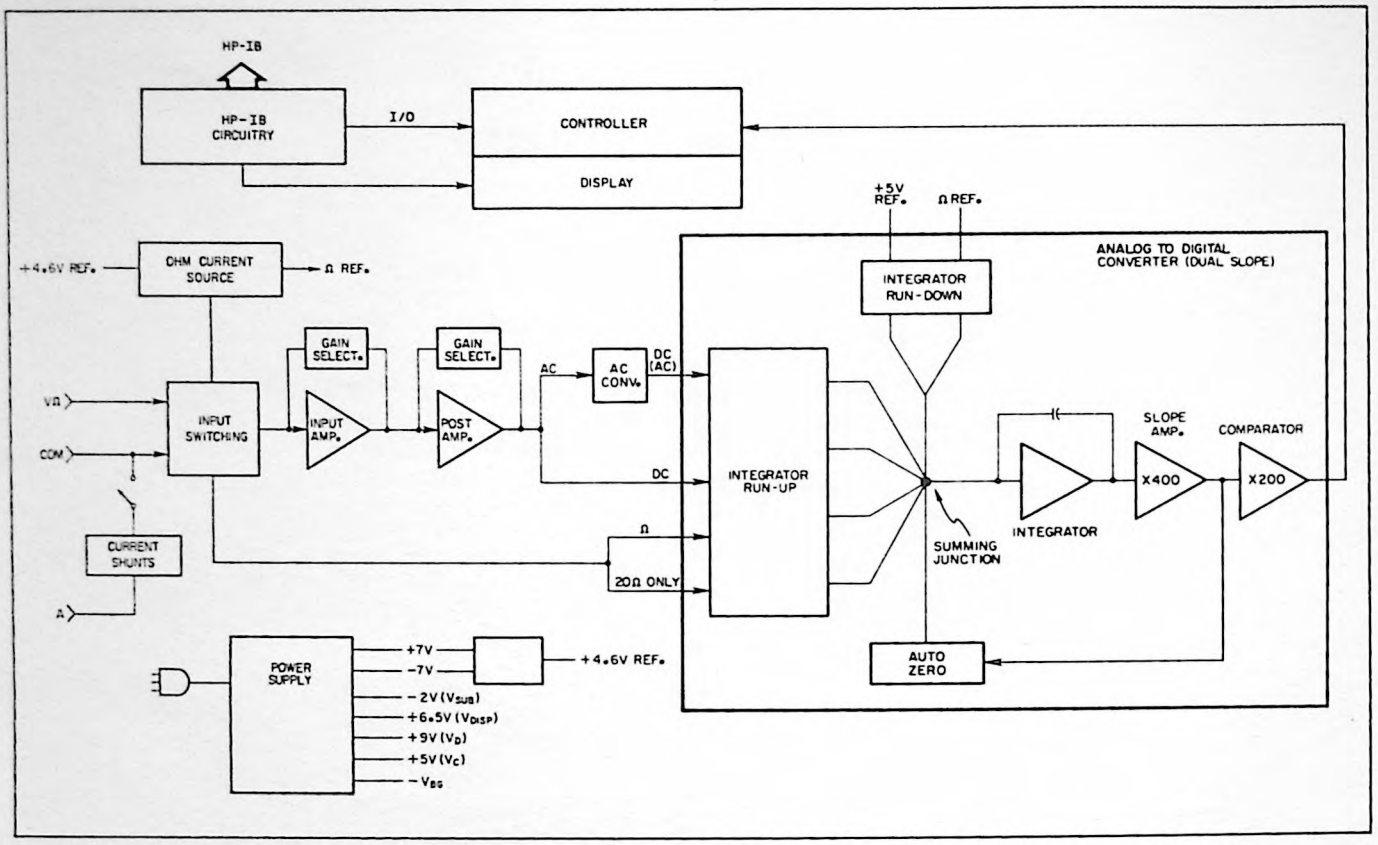


Figure 8-1. Simplified Block Diagram.

SECTION VIII
SERVICE

8-1. INTRODUCTION.

8-2. This section contains the Multimeter theory of operation and troubleshooting information. Also included are block diagrams, simplified schematics and complete Multimeter schematics.

8-3. The following sequence will be used in this section.

A. THEORY OF OPERATION.

1. Block Diagram and Simplified Theory.

2. Detailed Theory.

B. TROUBLESHOOTING.

C. SIMPLIFIED SCHEMATICS.

D. COMPLETE SCHEMATICS.

THEORY OF OPERATION

8-4. Block Diagram and Simplified Theory.

8-5. Figure 8-1 is a block diagram of the Multimeter. Each block is discussed to give the basic theory of operation of the Multimeter from input to display.

8-6. Input Switching. The input switching block consists of the Function switches and the Range switches. These switches program the controller using a 3 line function code (FNA, FNB, FNC) and a 4 line range code (MRD, MRE, MRF, Auto).

8-7. Input Amplifier. The input amplifier is a multi-gain operational amplifier. It is used for all five input functions. The gain is selected by MOS FET switches which are controlled by the controller (U13) or by the manual range switches.

8-8. Post Amplifier. Ac and dc voltages are amplified by the post amplifier. The gain is x1 or x10 and is selected by MOS FET switches or by the controller (U13).

8-9. AC Converter. The AC Converter is an average responding detector used in ac voltage and ac current measurements. The output of the AC Converter is a dc voltage equal to the rms value of the ac input voltage. In the ac current function, the input voltage to the converter is the ac voltage drop across the current shunts, times the gain of the input and post amplifiers.

8-10. Ohms Current Source. The ohms current source provides ohms reference voltage for the analog to digital converter and it provides sense current to the "unknown resistance" for each of the 7 ohms ranges.

8-11. Current Shunts. The current shunts are used for ac and dc current measurements. The voltage drop across the shunt resistors is the input voltage to the input amplifier in the ac or dc milliamps function.

8-12. Analog to Digital Converter. The analog to digital converter use the *dual slope integration technique* to translate analog input signals into digital timing pulses.

8-13. Controller. The controller processes range and function information and provides digital control to MOS FET switches in the input and post amplifiers and the analog to digital converter. The controller also converts the comparator output (run down time) into appropriate digit and segment drive voltages to operate the display.

8-14. Display. The display provides an annunciated digital readout of the input signal using light emitting diodes.

8-15. Power Supply. The power supply provides dc voltages of +7, -7, -2 (V_{SUB}), and 6.5 V (V_{DISP}) to the A1 Multimeter circuitry. An additional +9 V (V_D), +5 V (V_C), and V_{BG} (U725 Back Gate Bias) are also provided for the HP-IB logic circuitry.

8-16. DETAILED THEORY.

8-17. Power Supply.

8-18. +7 V Power Supply. The +7 V Power Supply is fullwave rectified by CR403 and CR404 and regulated by U10. The +7 V supply is adjustable by R417.

8-19. -7 V Power Supply. The -7 V Power Supply is fullwave rectified by CR405 and CR406 and regulated by U9 and Q403. The +7 V supply provides the reference for the -7 V supply as shown in Figure 8-2.

8-20. -2 V (V_{SUB}) Power Supply. The V_{SUB} Supply is the substrate or back gate bias supply for U11 (Input Hybrid), U12 Integrator Hybrid, and U13 Controller. This supply is derived by dividing by -7 V supply across R414 and R415. The V_{SUB} Supply is not regulated and is therefore, load sensitive. This factor is an aid in troubleshooting.

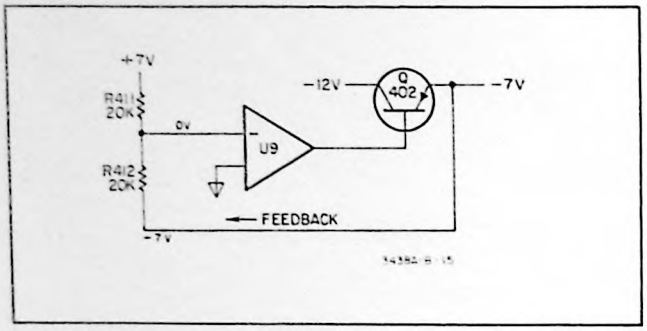


Figure 8-2. -7 V Regulator.

8-21. +6.5 V (V DISP) Power Supply. The V DISP Supply is fullwave rectified by CR402 and CR401 and regulated by series regulator Q402. Q402 gets its reference from the +7 V Supply.

8-22. +9 V (V D) Power Supply. The V D Supply is fullwave rectified by CR601 and CR602 and regulated by U601. U601 is a three pin 5 V regulator. CR607 references U601 at 3.92 V instead of ground. Therefore, the output voltage is a non-adjustable 8.55 to 9.45 volts.

8-23. +5 V (Vc) Power Supply. The Vc Supply is fullwave rectified by CR605 and CR606 and regulated by U602. U602 is again a three pin 5 V regulator, however, in this application it is referenced to ground.

8-24. V BG Power Supply. The V BG Supply is a Zener regulated (CR608 - 5.62 V) supply that is fullwave rectified by CR603 and CR604. The output is adjustable from -2 V to -5 V by R603. The V BG supply should be set to the voltage stamped on U725.

8-25. Analog Theory.

8-26. Input Switching. The input switches are separated into two groups—Function (S2 thru S6) and Range (S7 thru S14). The function switches provide correct paths for the input signals to the analog circuitry and at the same time output a three line function code which programs the Digital Control IC (U13), the Input Hybrid (U11), and the Integrator Hybrid (U12). The simplified analog schematic (Figure 8-12) shows the input switching configuration for each function. Table 8-1 shows the input switching configuration for each function. Table 8-1 shows the three line function codes for each of the five Multimeter functions.

Table 8-1. Function Code.

Function	Code FNA	FNB	FNC
DCV (S2)	1	1	0
ACV (S3)	1	0	1
DCI (S4)	1	0	0
ACI (S5)	0	0	0
Ω (S6)	1	1	1

8-27. The range switches (S7 thru S13) output a three line range code to U13, U11, and U12 when the AUTO (S14) switch is not depressed. If (S14) is depressed, S7 thru S13 are open and the range code information then comes from the Control IC (U13). Table 8-2 shows the range codes and Figure 8-3 shows a block diagram of the logic interface during Auto and Manual ranging.

Table 8-2. Range Codes.

Range	Code RGD	RGE	RGF	Auto
20 mV (S7)	0	1	0	1
200 mV (S8)	0	0	0	1
2 V (S9)	1	0	0	1
20 V (S10)	1	1	0	1
200 V (S11)	1	1	1	1
1200 V (S12)	0	1	1	1
20 MΩ (S13)	0	0	1	1
Auto (S14)	Open	Open	Open	0

8-28. Voltage and ohms functions can be Auto or Manually ranged. The current function (dcI and acI) are manually range only. S8 thru S12 are used to select the correct current shunt for the five current ranges.

8-29. DC Voltmeter. The Simplified Analog Schematic (Figure 8-12) shows the DC Voltmeter circuit configuration. The function of the analog portion of the Multimeter is to convert voltage, current, or resistance information at the input terminals to a dc voltage at the input to the Analog to Digital Converter (A to D Converter). In the dc voltmeter configuration, the voltage at reference point (B) can vary from 0 Vdc to ± 1200 Vdc.

8-30. The voltage at the input to the A to D Converter (D) needs to stay within the limits of -1 Vdc to +1 Vdc to avoid setting the Multimeter display to an overload (OL)

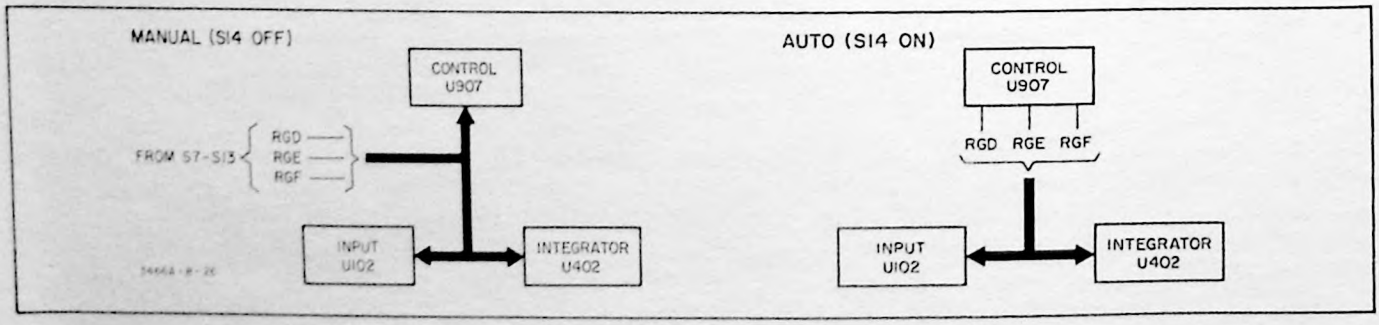


Figure 8-3. Range Code Logic Interface.

condition. The input voltage Ⓑ must obviously be amplified or attenuated to keep the voltage at Ⓓ within these limits. This is accomplished by the combined gains of the Input and Post amplifiers. Figure 8-4 shows the gain configuration for each of the five dc ranges.

8-31. The input voltage at Ⓑ is applied to the input amplifier during integrator run-up only. Consequently, the input voltage to the Input Amplifier is a square wave as shown in Figure 8-4.

8-32. AC Voltmeter. The AC Voltmeter circuit configuration is shown in the Analog Simplified Schematic (Figure 8-12). Figure 8-5 shows the gain configuration for each of the five ac ranges.

8-33. In the AC Voltmeter configuration the output of the Post Amplifier Ⓓ is the input to the Ac to Dc Converter. This signal will be ac in the ac volts or ac milliamps function.

8-34. U6 and its associated components comprise the Ac to Dc Converter. The output is a dc voltage equal to the rms value of the input. The output of the Ac to Dc Converter becomes the run-up voltage for the A to D Converter.

8-35. Ohmmeter. Refer to the Simplified Analog Schematic for a simplification of the Ohmmeter circuit configuration. Figure 8-6 is a block diagram of the Ohmmeter circuit.

8-36. U8 functions as a low impedance voltage source to Rref. It outputs .5 V in all ohmmeter ranges. This output voltage is dropped across Rref to a virtual ground provided by the Input Amplifier (—). The resultant current is the current thru the unknown resistance (Rx). Figure 8-7 further simplifies the gain configuration combining the Input Amplifier, associated compensation, and protection circuitry as an inverting Op Amp with Rref as the input resistor and Rx as the feedback resistor. The output of the Input Amplifier is the run-up voltage to the A to D Converter.

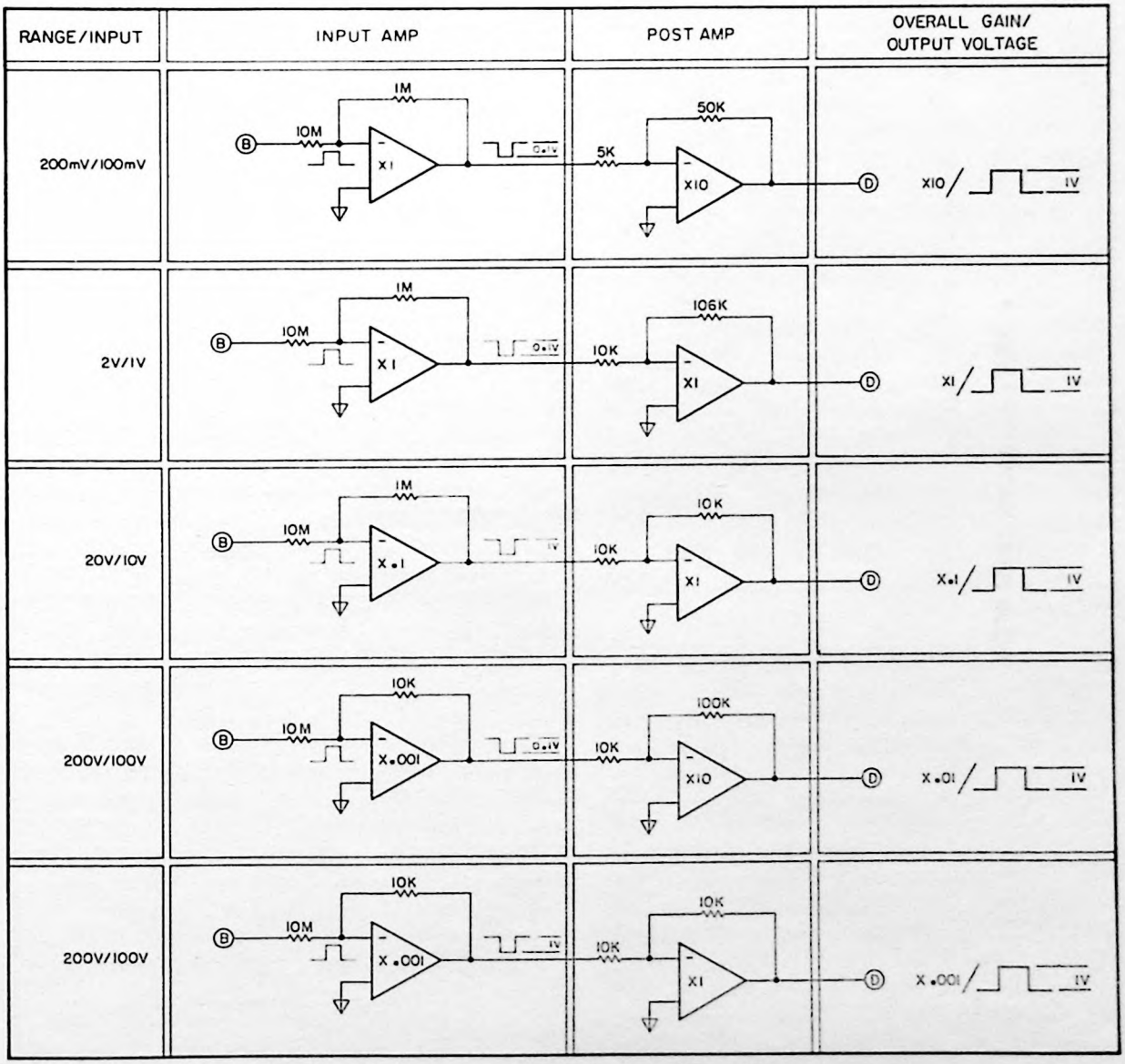


Figure 8-4. DC Gain Configuration.

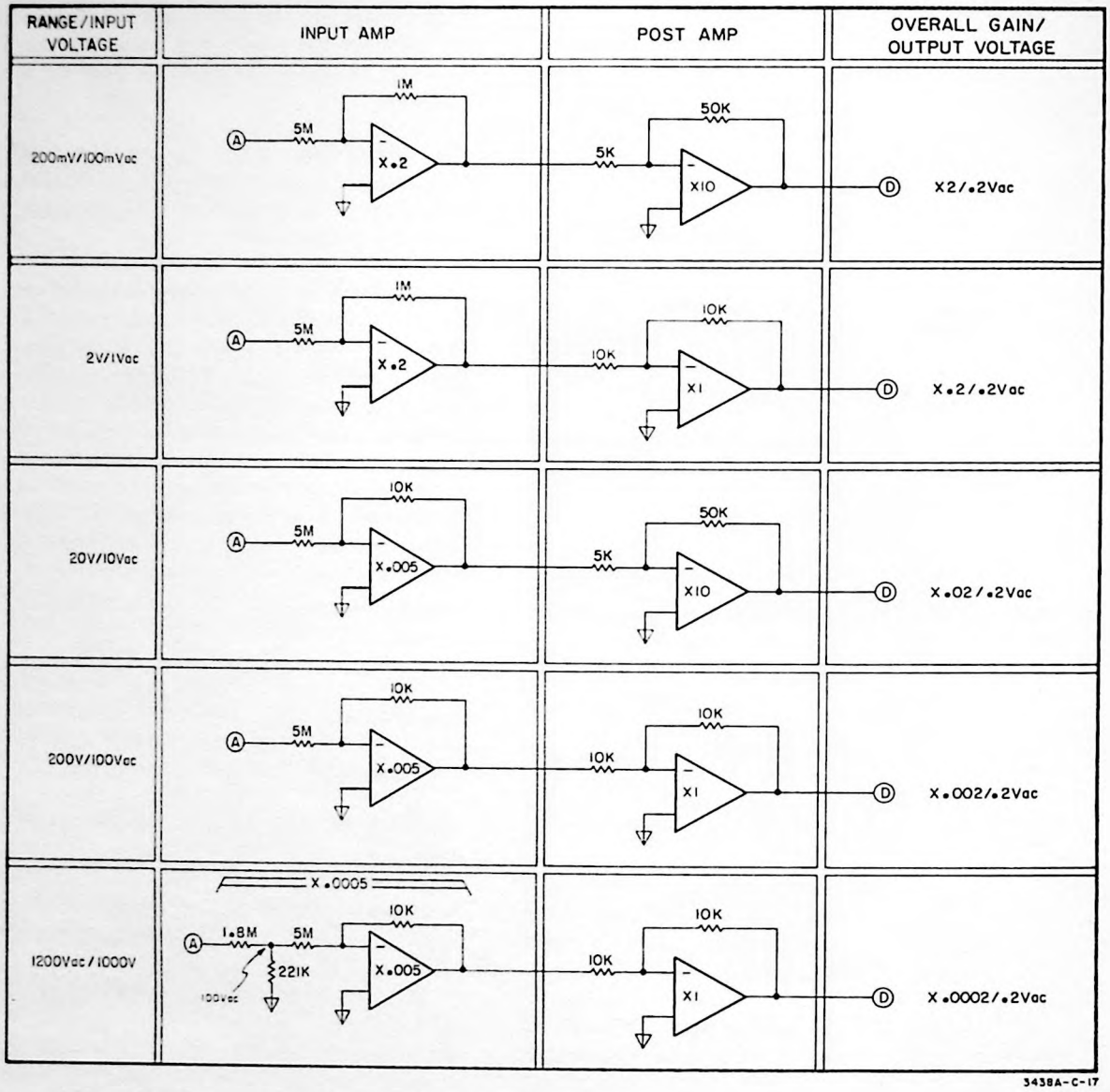


Figure 8-5. AC Gain Configurations.

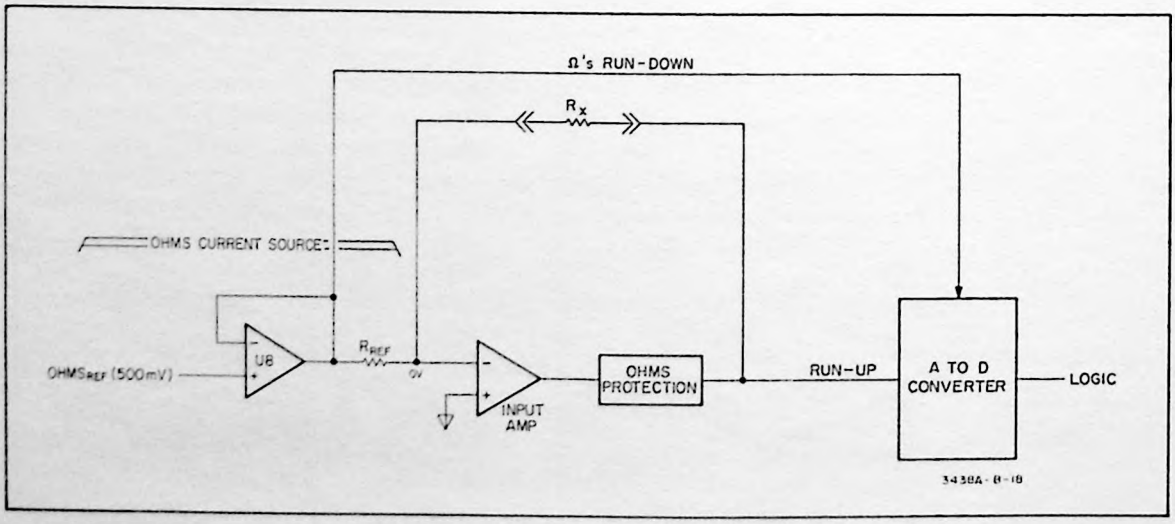
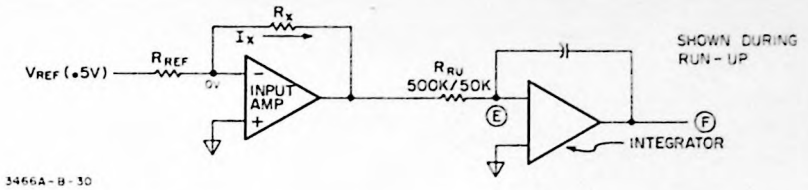


Figure 8-6. Ohms Block Diagram.



Range (Ω)	Vref	Rref (Ω)	Rx (Ω) (1/2 Scale)	Ix (mA)	Input Amp Output	RRU (Ω)	Integrator Output
20 M	.5 V	*10 M	10 M	.00005	- .5 V	500 K	
2 M	.5 V	1 M	1 M	.0005	- .5 V	500 K	
200 K	.5 V	100 K	100 K	.005	- .5 V	500 K	Ramp (+)
20 K	.5 V	10 K	10 K	.05	- .5 V	500 K	
2 K	.5 V	1 K	1 K	.5	- .5 V	500 K	0 V
200	.5 V	100	100	5	- .5 V	500 K	
20	5 V	100	10	5	- .05 V	50 K	

*10 MΩ Effective Resistance

Figure 8-7. Ohm Gain.

8-37. Analog to Digital Converter (A to D Converter). Refer to Figures 8-8, 8-12, and 8-14. The A to D Converter converts dc voltage into a proportional timer control signal. This circuit consists of an Integrator (U2), a Slope Amplifier (U3), a Comparator (U4), and an Auto Zero Loop.

8-38. There are four basic conditions (①②③④) for a complete measurement cycle as shown in Figure 8-8. These conditions exist for each of the five Multimeter functions.

8-39. During Auto Zero ① the exact potential at the Integrator summing junction is stored on C205. This potential should be nearly zero volts. However, any offset voltages at the input to the Integrator will be stored during condition ①.

8-40. At the beginning of run-up ② a dc voltage proportional to the Multimeter input is applied across one of the run-up resistors (depending on the Multimeter function selected). This run-up voltage is integrated across C202. The polarity of the Integrator output is opposite to the run-up voltage polarity. The run-up voltage polarity is dependent upon the Multimeter function, range selected, and the input polarity. Figure 8-8 shows the Integrator output for three different input levels and the polarity for different functions and input polarities.

8-41. Run-up is a fixed time of 100 milliseconds. At the end of run-up the run-up resistor is disconnected from the integrator summing junction. There is now a 1.6 millisecond hold or settling time ③ before run-down is initiated. During this time the Controller senses the polarity of the Integrator output and selects the proper run-down current. If the integrator output is positive at the end of run-up, QH1 will be closed and QH2 open during run-down. If the integrator output is negative QH1 and QH2 will be open.

8-42. Run-down ④ time may vary from zero to 200 milliseconds depending on the charge built up on C202 during run-up. During run-down the discharge rate of C202 is fixed (fixed slope). Therefore, the greater the charge on C202 (positive or negative), the longer the discharge time. This conversion method from voltage to time is called Dual Slope Integration. A counter is started at the beginning of run-down and runs until the output of the Integrator crosses zero. The accumulated time is directly proportional to the dc voltage at the input to the A to D Converter. This time is processed by the Controller along with the range and function information that is already established to become the Multimeter display readout.

8-43. The Slope Amplifier and Comparator amplify the output of the Integrator by a factor of X80000. This provides a very accurate zero crossing detector. If the output of the Integrator is positive during run-up, the Comparator output will be positive. This voltage is sensed and processed by the controller to provide correct run-down and display information. The comparator output will remain positive until the output of the Integrator runs down and crosses zero volts. The comparator then changes to zero volts output.

8-44. Controller. U13 functions as an Algorithmic State Machine (ASM) controller. It controls the MOS FET switching on the Input and Integrator Hybrids. U13 outputs drive signals for the display digits.

8-45. At the end of run-down, the output of the A to D Converter (Comparator) is a *state change* HI to LO or LO to HI, depending on the polarity of the Integrator output. As previously discussed, the display counter has been counting since the beginning of run-down. Now, the counter must be stopped exactly as the Comparator state changes to ensure accurate A to D Conversion. The comparator output stops the controller counter. The information now stored in the counter is a true representation of the Multimeter Input.

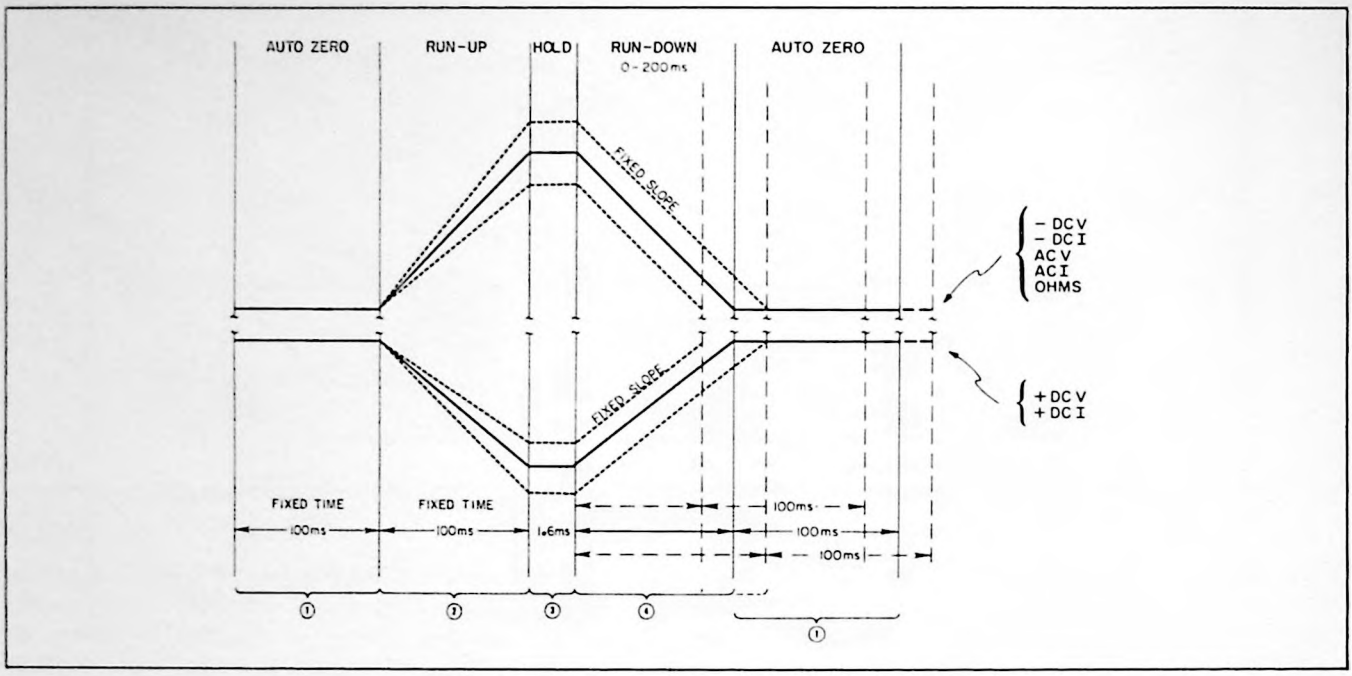


Figure 8-8. Integrator Output.

8-46. HP-IB Theory. The HP-IB is an instrumentation interface which simplifies the integration of instruments, calculators, and computers in a system.

NOTE

HP-IB is Hewlett-Packard's implementation IEEE Std. 488-1975, "Standard Digital Interface for Programmable Instrumentation".

8-47. The HP-IB employs a bus of 16 active signal lines grouped into three sets:

(1) Data

(2) Data Byte Transfer Control

(3) General Interface Management

Up to 15 instruments can be interconnected in one HP-IB system. Figure 8-9 is a pictorial of the Interface Connections and Bus Structure.

8-48. Eight of the signal lines are termed DATA lines and are used to carry coded messages. The coded messages may represent addresses, program data, measurements, or status bytes. The same DATA lines are used for input and output of messages in a bit-parallel, byte-serial form. Normally, a seven-bit ASCII code is used with the eighth bit available for Parity Checking.

8-49. Data is transferred by means of an interlocked "handshake" technique which permits asynchronous communication or data transfer at the rate of the slowest

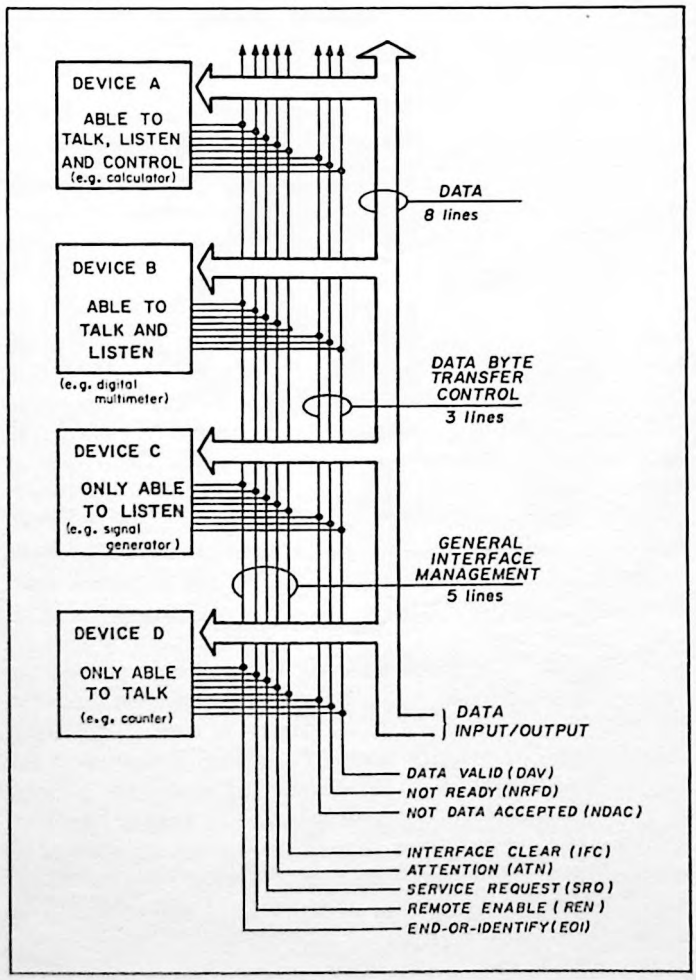


Figure 8-9. Interface Connections and Bus Structure.

device participating in that particular conversation. The three **Data BYTE Transfer CONTROL** lines are used to implement the handshake technique.

8-50. The remaining five **GENERAL INTERFACE MANAGEMENT** lines are used for such things as activating all the connected devices at once, clearing the interface, etc. Refer to Table 8-3 for the definition of each of the management lines.

Table 8-3. General Interface Management Lines.

Name	Mnemonic	Description
Attention	ATN	DETERMINES the Operating mode
Interface Clear	IFC	INITIALIZES the HP-IB system to an idle state (no activity on the BUS)
Service Request	SRQ	ALERTS the Controller to a need for Communication
Remote Enable	REN	PLACES instruments under remote program control
End of Identity	EDI	INDICATES last data transition during a data transfer sequence

TROUBLESHOOTING

8-51. Preliminary Troubleshooting.

8-52. Troubleshooting procedures are performed after it is established that there is a failure in the Multimeter circuitry. Unless a failure is obvious, such as a blank display, refer to the Adjustment Procedures and Abbreviated Performance Checks before attempting to troubleshoot the Multimeter.

CAUTION

The hybrid circuits in the Multimeter may be permanently damaged by static discharge from a hand or tool when the Multimeter is disassembled. The procedures below must be followed to prevent possible damage.

1. Ground the hand while disassembling and working on the Multimeter. Conductive wristbands (-hp- Part No. 00970-67900) are available for this purpose.

2. Attach the Multimeter COM terminal to earth ground. Touch all tools to earth ground to remove static charges before using them on the Multimeter.

3. Use a soldering iron with a grounded tip.

CAUTION

Wear clean cotton gloves when working on the circuit board. Contamination or fingerprints will reduce the accuracy of the Multimeter. Use low flux content solder (-hp- Part No. 8090-0512) when replacing components. Do not permit traces of flux to form on the circuit board. Observe precautions against static discharge. Do not use flux remover.

8-53. Front Panel Observations. Without disassembling the Multimeter, failures can often be isolated by doing the Abbreviated Performance Tests and by carefully observing and recording the display indications. This is especially true if the failure is a measurement error.

8-54. Refer to Table 8-4 AC Gain, 8-5 DC Gain, and Figure 8-12. Simplified Analog Schematic for the following examples.

NOTE

Circled letters Ⓐ through Ⓕ are reference points to aid in correlating between block, simplified, and complete schematic diagrams.

Table 8-4. AC Gain.

	Ⓐ			Ⓓ
Range	Input Voltage	Input Amp (Gain)	Post Amp (Gain)	Post Amp Output
200 mV	.1 V	.2	x 10	200 mV
2 V	1 V	.2	x 1	200 mV
20 V	10 V	.002	x 10	200 mV
200 V	100 V	.002	x 1	200 mV
1200 V	1 kV	.0002	x 1	200 mV

Table 8-5. DC Gain.

	Ⓑ			Ⓓ
Range	Input Voltage	Input Amp (Gain)	Post Amp (Gain)	Post Amp Output
200 mV	100 mV	X 1	X 10	1 V
2 V	1 V	X 1	X 1	1 V
20 V	10 V	X .1	X 1	1 V
200 V	100 V	X .001	X 10	1 V
1200 V	1000 V	X .001	X 1	1 V

8-54(a). 100 kHz frequency response failures are most often associated with the ac to dc converter of the post amp x 10 gain. This failure can also be isolated by recording and evaluating the ranges that are in or out of specification.

Example 1:

200 mV	OUT
2 V	OUT

20 V	OUT
200 V	OUT
1200 V	OUT

The failure is probably associated with the ac to dc converter.

Example 2:

200 mV	OUT
2 V	IN
20 V	OUT
200 V	IN
1200 V	IN

The failure is probably associated with the post amp x 10 gain.

8-54(b). The functional block diagram can be used to isolate failures as follows:

Example 1:

acV	OUT
dcV	OUT
Ohms	OUT

The failure is probably associated with the input amp of the a to d converter.

Example 2:

acV	OUT
dcV	IN
Ohms	IN

The failure is probably associated with the ac to dc converter.

8-55. Disassembly Procedure. Once it has been established that there is a failure, disassemble the Multimeter using the following procedure:

a. Remove the Multimeter Power Cord.

b. Remove two top cover fastening screws (back panel) and remove top cover.

c. Remove five A3 shield mounting screws (back panel). This will allows the A3 PC and shield assembly (HP-IB) to slide forware ⅜ of an inch.

d. Disconnect W5 from the A3 PC assembly. W5 is a green, yellow, orange, red, brown cable connecting A3 to A2 (display).

e. Remove the A3 PC and shield assembly by sliding the assembly forward and upward. With the Multimeter front panel facing you, place the A3 PC and shield assembly to the right side of the Multimeter.

f. Re-connect W5 to the A3 PC assembly.

g. All adjustments can be made without removing the interval A1 shield.

8-56. General Troubleshooting Information.

8-57. Test Jumpers. Test jumpers (JM) are strategically located on the A1 and A3 PC assemblies to aid in troubleshooting. In some locations JM's can be clipped open for circuit isolation. Table 8-6 lists the A1 JM's and their function.

NOTE

The letter J etched on the A1 PC assembly denotes the JM designator on the schematics.

Table 8-6. Test Jumpers.

JM Number	Voltage/Signal	Usage
JM 1	External Hold	Holds Display
JM 2	10 kHz Test	Test Only
JM 102	Input Amp Output	↓
JM 103	Post Amp Output	↓
JM 201	Slope Amp Output	↓
JM 202	Comparator Output	↓
JM 203	Run up Clock	Test Only
JM 401	V_{disp} Supply	When Opened
JM 402	V_{sub} -2 V Supply	disconnects V_{sub} from U11, U12, U13
JM 403	V_{sub} -2 V Supply	disconnects V_{sub} from U11
JM 404	V_{sub} -2 V Supply	disconnects V_{sub} from U12
JM 405	+ 7 V Supply	disconnects +7 V from U2, U3, U4, U5, U6, U7, U12
JM 406	+ 7 V Supply	disconnects +7 V from U5, U6, U7
JM 407	- 7 V Supply	disconnects - 7 V from U2, U3, U4, U5, U6, U7, U12
JM 408	- 7 V Supply	disconnects - 7 V from U5, U6, U7

8-58. Test Pads. Logic control states for the A1 PC assembly (Hi = + 7 V, Low = 0 V) can be evaluated using the test pads. Table 8-7 lists the test pad by number and its associated function.

Table 8-7. Test Pads.

No.	Usage	No.	Usage
1	Run Up Enable	6	MRE Manual Range Switch Code
2	FNA } Function	7	MRD Manual Range Switch Code
3	FNB } Switch	8	Digital Ground
4	FNC } Code	9	Run Down Compensation (+)
5	MRF Manual Range Switch Code	10	No Connection

8-59. Power Supply. If the +7 V and/or the -7 V supply reads low at the test pads, turn S1 OFF and re-check for +7 V and -7 V at a point prior to the S1. Refer to schematic no. 4. This will verify if the problem is in the power supply rather than in the Multimeter circuitry. Figure 8-10 shows the jumper configuration for the +7 V and -7 V power supplies.

8-60. V_{SUB} is the substrate voltage for U11, U12, and U13. If this voltage is incorrect, individually opening JM 403, JM 404, and JM 402 while monitoring the V_{SUB} voltage will isolate the faulty integrated circuit.

8-61. A1 and A2 Troubleshooting.

8-62. Analog Troubleshooting. Failures in the analog circuitry can best be analyzed by studying the Simplified Analog Schematic, Figure 8-12.

NOTE

Disconnect J403 (A3 I/O) while verifying the A1 and A2 Multimeter Operations.

8-63. The Input and Post Amplifiers can be isolated by placing a short between the COM and Amps input terminals. This forces the Multimeter into Auto Zero. Therefore, the outputs of either Amplifier should be approximately zero volts. If both amplifiers are offset significantly from zero, troubleshoot the Input Amplifier first.

8-64. The gains for the Input and Post Amplifiers can be verified by stopping the measurement cycle during run-up. This is accomplished by shorting U13(35) to ground during run-up. This stops the controller clock and leaves the gain selector switches set for run-up. A dc voltage can be used in each range to signal trace the stage gain of the Input and Post Amplifiers.

8-65. Logic Troubleshooting. The Multimeter Logic can best be tested by the following procedure:

a. With J403 still disconnected – open JM202.

b. Connect the controller (U13) side of JM202 to JM203.

c. The display to indicate all zeros except when a "Improper" switch combination is selected (Refer to Section III).

8-66. If this test fails, there is a problem in the Logic portion of the Multimeter. If it passes, the problem is most likely to be in the Analog portion.

NOTE

The Adjustment Procedure must be performed and the Abbreviated Performance Test completed before assuming the Multimeter has failed. Many hours of troubleshooting can be waisted because of an overlooked adjustment.

8-67. HP-IB (A3) Troubleshooting.

8-68. The A3 PC assembly can best be troubleshot using the -hp- 5004A Signature Analyzer (SA) and the Troubleshooting Flow Charts given in Figure 8-11.

8-69. Signature Analyzer (SA). Throughout the following Flow Chart, the SA switch settings and connectors will be given except the ground lead connection. The ground lead is connected to the GND jumper on the A3 PC assembly for the entire test.

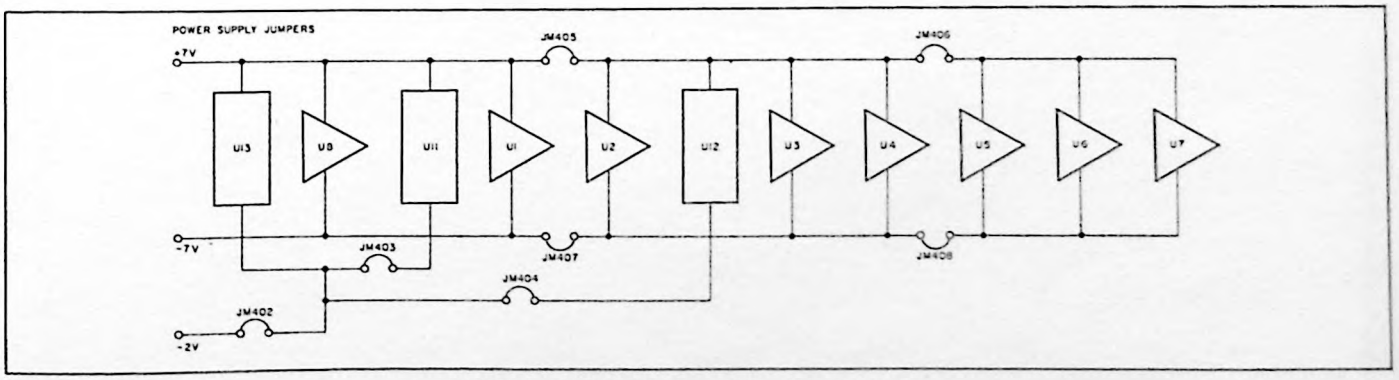
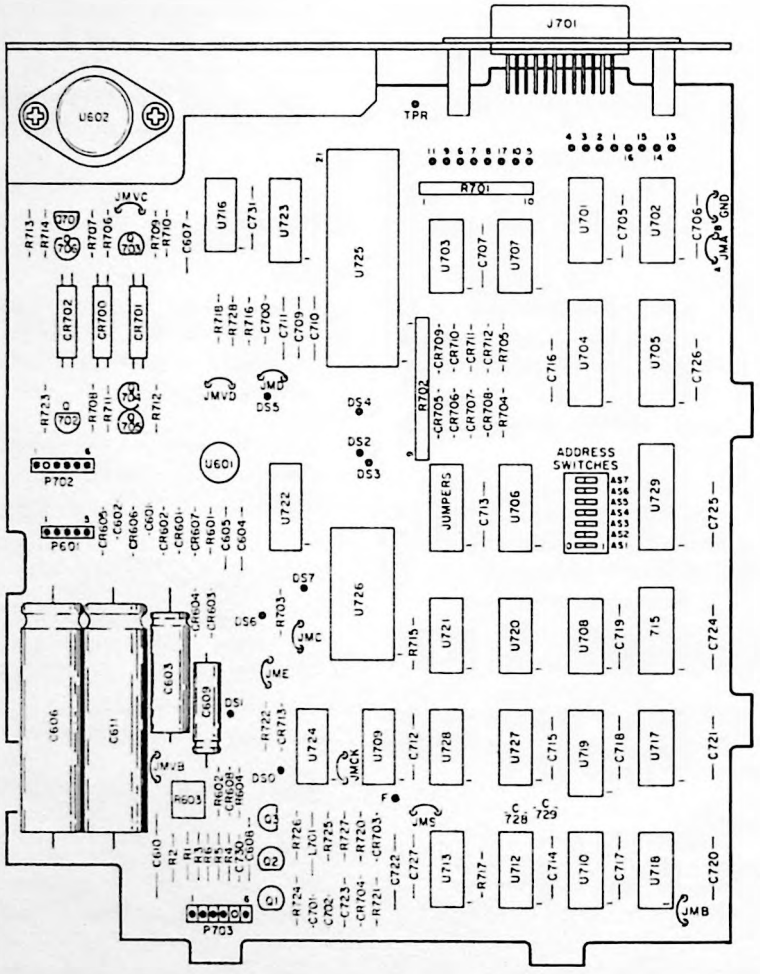


Figure 8-10. Power Supply Jumpers.


J701
U602
TPR
R701
U716
U723
U725
U703
U707
U701
U702
C731
C705
C706
GND
JMC
JMD
JME
JMF
JMA
JMB
JMS
CR702
CR700
CR701
R713
R714
R707
R706
R709
R710
C607
R718
R728
R716
C700
C711
C709
C710
R723
R708
R711
R712
DS5
DS4
DS2
DS3
R702
CR705
CR706
CR707
CR708
CR709
CR710
CR711
CR712
R705
R704
U704
U705
C716
C726
P702
U601
ADDRESS SWITCHES
P601
U722
U726
JUMPERS
U706
U729
C713
C725
CR606
C602
CR606
C601
CR602
CR601
CR607
R601
C605
C604
DS7
DS6
R703
CR604
CR603
U721
U720
U708
715
R715
C719
C724
C606
C611
C603
C609
DS1
DS0
R722
CR713
U724
U709
U728
U727
U719
U717
C712
C715
C718
C721
R603
CR603
CR604
R604
R603
C730
C608
C610
R2
R1
R4
R5
R6
R3
C701
L701
C702
R726
R725
R727
R720
CR703
C722
C727
C728
C729
U713
U712
U710
U718
R724
C701
C702
C723
CR704
R721
R717
C714
C717
C720
P703
A3
03438-66503
3438A 9 8

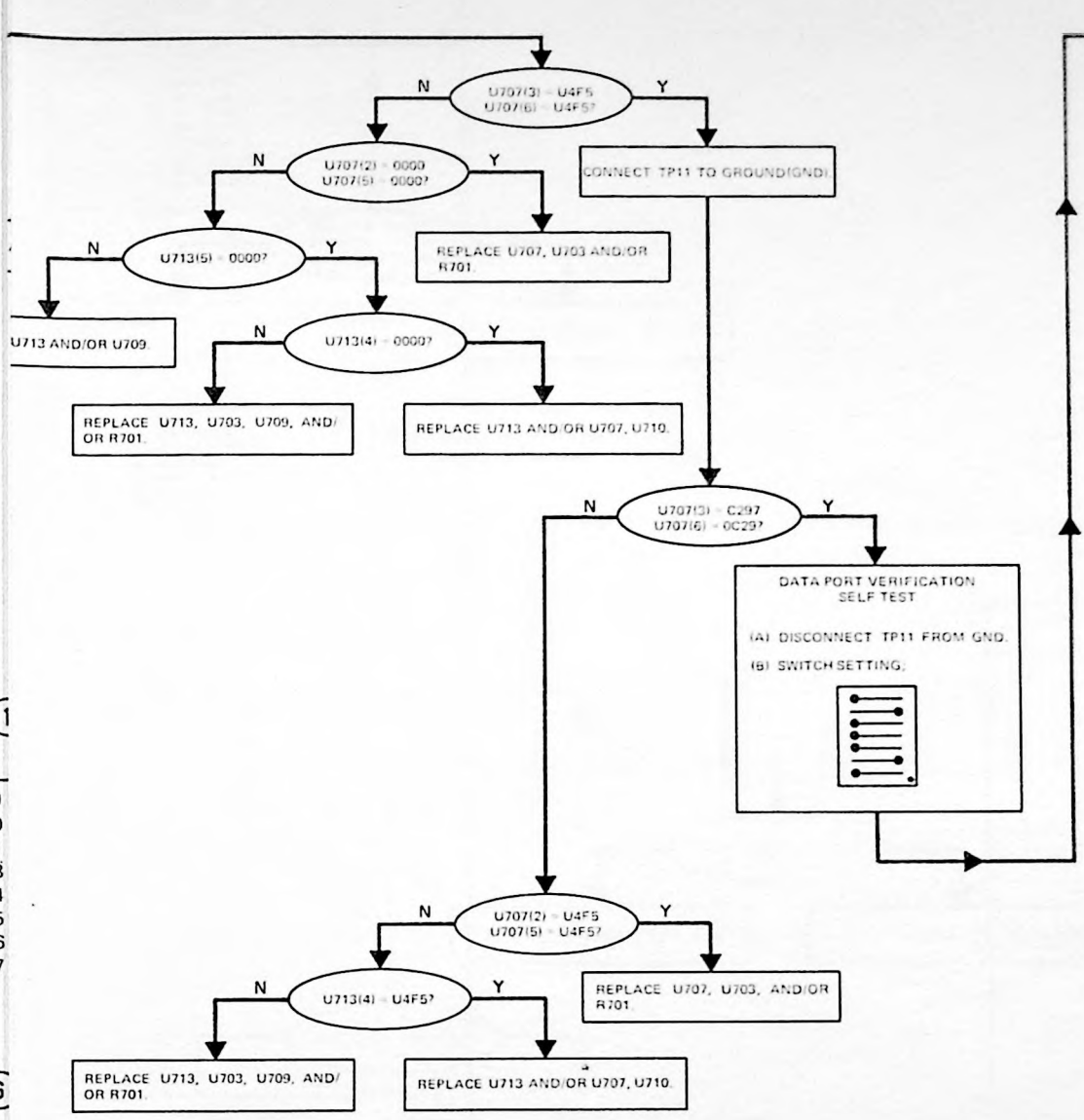


Figure 8-11. HP-IB Troubleshooting Flowchart.

HP–IB LOGIC TROUBLESHOOTING

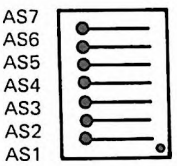
NOTES

Y = YES OR OK
N = NO OR BAD
SA = SIGNATURE ANALYZER

IF THE GATE ON THE SIGNATURE ANALYZER FAILS TO TRIGGER, TROUBLESHOOT THE DEVICES (THE IC'S) TO WHICH START, STOP, AND CLOCK ARE ATTACHED.

SIG. SET = SA SIGNATURES FOR PARTICULAR DEVICE. REFER TO APRON PAGE.

ADDRESS SWITCHES:



SIGNATURE SETS
(SIGNATURE ANALYZER DISPLAY INDICATION)

(1) U726

Pin		
	9	1CFH
	10	C9U0
	11	7P16
	13	7P00
	14	4698
	15	3UU5
	16	0130
	17	1CHP

(2) U725

Pin		
	1	C21A
	2	HA07
	3	H0AA
	4	P030
	5	4442
	6	4U2A
	7	0772
	8	9635
	9	1734
	10	8P54
	26	7A70

(3) U726

Pin		
	9	P82C
	10	0H72
	11	A52H
	13	042H
	14	15PF
	15	F497
	16	234F
	17	U8P3

(4) U729

Pin		
	2	0H26
	4	C487
	6	3U46
	8	9C2H
	12	55A8
	14	9314
	16	42A6
	18	A4FU

(5) U729

Pin		
	2	52C9
	4	PC18
	6	60H9
	8	F4C2
	12	0A37
	14	9314
	16	42A6
	18	UC50

(6) U722

Pin		
	1	4566
	2	1AU9
	3	1AU9
	4	1AU9
	5	0000

(7) U729

Pin		
	3	0H02
	5*	A026 or 07A7
	7	838U or 240P
	9	9817 or 3U96
	11	144F or C3FH
	13	H550 or 72H1
	15	0661
	17	6FF2 or FC43

(8) U729

Pin		
	2	0H02
	4	07A7
	6	240P
	8	3U96
	12	C3FH
	14	H550
	16	0661
	18	FC43

(9) U722

Pin		
	1	C0C2
	2	9111
	3	APUF
	4	APUF
	5	0000

(10) U715

Pin		
	2	155C
	7	2UA0
	10	CH88
	12	FHA8

* Pin 5 may be unstable.

(11) U705

Pin		
	2	8556
	5	84H2
	6	91U1
	9	F9AA

(12) U722

Pin		
	1	407A
	2	6800
	3	C2PC
	4	8PH0
	5	0000

(13) U705

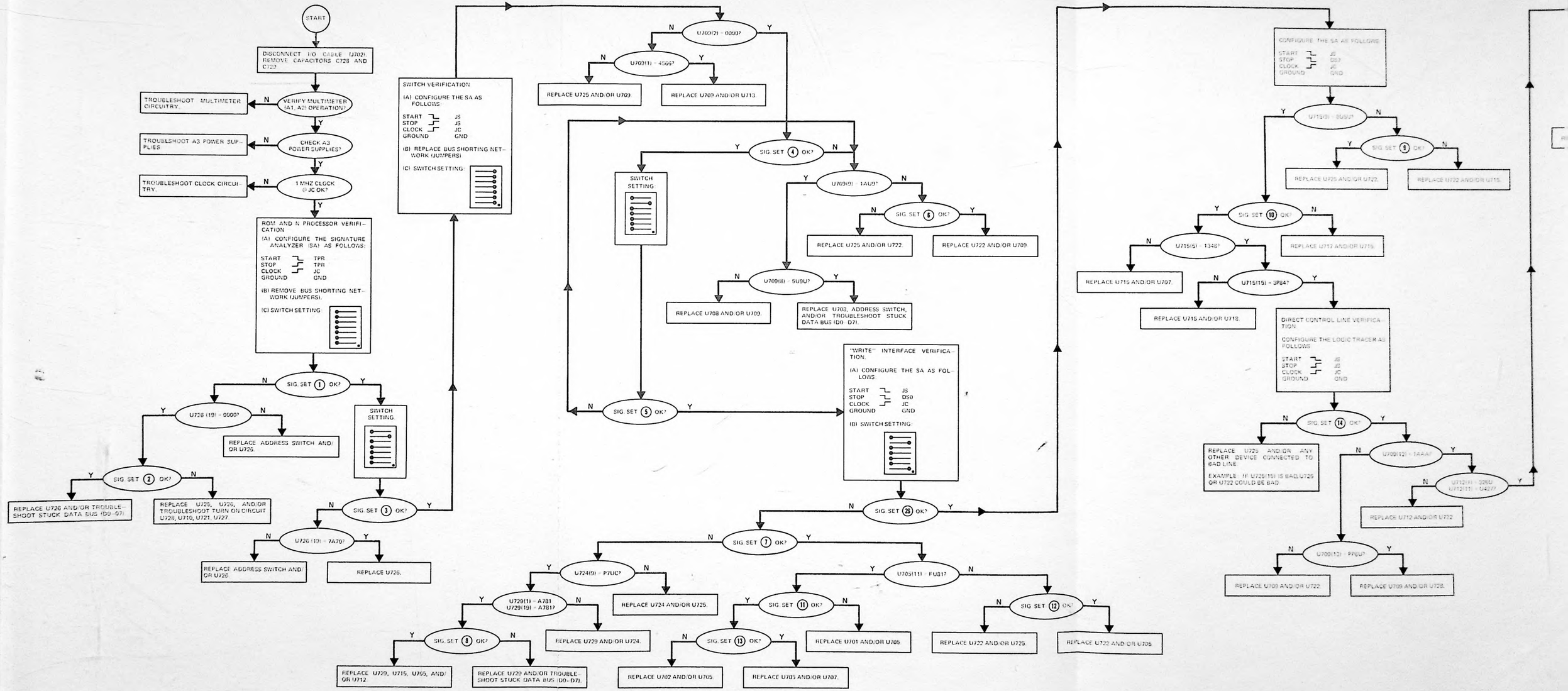
Pin		
	12	8CP8
	15	AU62
	16	736A

(14) U725

Pin		
	12	CP32
	13	6949
	14	6966
	15	28F5
	31	U4F5
	32	0000 or U4F5
	33	H987
	34	U4F5
	35	UUPF
	36	4652
	37	HHCA

(26) U705

Pin		
	2	8556
	5	84H2
	6	91U1
	9	F9AA
	12	8CP8
	15	AU62
	16	736A
	19	4UA1


START
DISCONNECT I/O CABLE (J702). REMOVE CAPACITORS C728 AND C722.
VERIFY MULTIMETER (A1, A2) OPERATION?
N
TROUBLESHOOT MULTIMETER CIRCUITRY.
Y
CHECK A3 POWER SUPPLIES?
N
TROUBLESHOOT A3 POWER SUPPLIES.
Y
1 MHZ CLOCK @ JC OK?
N
TROUBLESHOOT CLOCK CIRCUITRY.
Y
ROM AND N PROCESSOR VERIFICATION
(A) CONFIGURE THE SIGNATURE ANALYZER (SA) AS FOLLOWS:
START JS
STOP TPR
CLOCK TPR
GROUND JC
GND
(B) REMOVE BUS SHORTING NETWORK (JUMPERS).
(C) SWITCH SETTING:
SIG. SET (1) OK?
N
Y
U726 (19) = 0000?
N
Y
REPLACE ADDRESS SWITCH AND/OR U726.
SIG. SET (2) OK?
Y
N
REPLACE U726 AND/OR TROUBLESHOOT STUCK DATA BUS (D0-D7).
REPLACE U725, U726, AND/OR TROUBLESHOOT TURN ON CIRCUIT U726, U710, U721, U727.
SWITCH SETTING:
SIG. SET (3) OK?
N
Y
U726 (19) = 7A70?
N
Y
REPLACE ADDRESS SWITCH AND/OR U726.
REPLACE U726.
SWITCH VERIFICATION
(A) CONFIGURE THE SA AS FOLLOWS:
START JS
STOP JS
CLOCK JC
GROUND GND
(B) REPLACE BUS SHORTING NETWORK (JUMPERS)
(C) SWITCH SETTING:
U760(9) = 0000?
N
Y
U760(1) = 4566?
N
Y
REPLACE U725 AND/OR U760.
REPLACE U760 AND/OR U713.
SIG. SET (4) OK?
Y
N
SWITCH SETTING:
U760(9) = 1AU9?
Y
N
SIG. SET (6) OK?
N
Y
REPLACE U725 AND/OR U722.
REPLACE U722 AND/OR U760.
U760(8) = 5U9U?
N
Y
REPLACE U760 AND/OR U760.
REPLACE U760, ADDRESS SWITCH, AND/OR TROUBLESHOOT STUCK DATA BUS (D0-D7).
SIG. SET (5) OK?
N
Y
"WRITE" INTERFACE VERIFICATION.
(A) CONFIGURE THE SA AS FOLLOWS:
START JS
STOP DS0
CLOCK JC
GROUND GND
(B) SWITCH SETTING:
SIG. SET (26) OK?
N
Y
SIG. SET (7) OK?
N
Y
U724(9) = P7UC?
Y
N
U729(1) = A781
U729(19) = A781?
Y
N
REPLACE U724 AND/OR U725.
SIG. SET (8) OK?
Y
N
REPLACE U729 AND/OR U724.
REPLACE U729, U715, U705, AND/OR U712.
REPLACE U729 AND/OR TROUBLESHOOT STUCK DATA BUS (D0-D7).
U705(11) = FU81?
Y
N
SIG. SET (11) OK?
Y
N
SIG. SET (13) OK?
N
Y
REPLACE U702 AND/OR U705.
REPLACE U705 AND/OR U707.
REPLACE U701 AND/OR U705.
SIG. SET (12) OK?
N
Y
REPLACE U722 AND/OR U725.
REPLACE U722 AND/OR U705.
CONFIGURE THE SA AS FOLLOWS:
START JS
STOP JS?
CLOCK JC
GROUND GND
U715(9) = 8U9U?
Y
N
SIG. SET (9) OK?
Y
N
REPLACE U725 AND/OR U722.
REPLACE U722 AND/OR U715.
SIG. SET (10) OK?
Y
N
U715(5) = 1348?
N
Y
REPLACE U715 AND/OR U707.
REPLACE U717 AND/OR U719.
U715(15) = 3P64?
N
Y
REPLACE U715 AND/OR U718.
DIRECT CONTROL LINE VERIFICATION.
CONFIGURE THE LOGIC TRACER AS FOLLOWS:
START JS
STOP JS
CLOCK JC
GROUND GND
SIG. SET (14) OK?
N
Y
REPLACE U725 AND/OR ANY OTHER DEVICE CONNECTED TO BAD LINE.
EXAMPLE: IF U725(15) IS BAD, U725 OR U722 COULD BE BAD.
U709(12) = 1AAA?
N
Y
U712(1) = 326U
U712(11) = U427?
N
Y
REPLACE U712 AND/OR U722.
U709(12) = P9GU?
N
Y
REPLACE U709 AND/OR U722.
REPLACE U709 AND/OR U726.

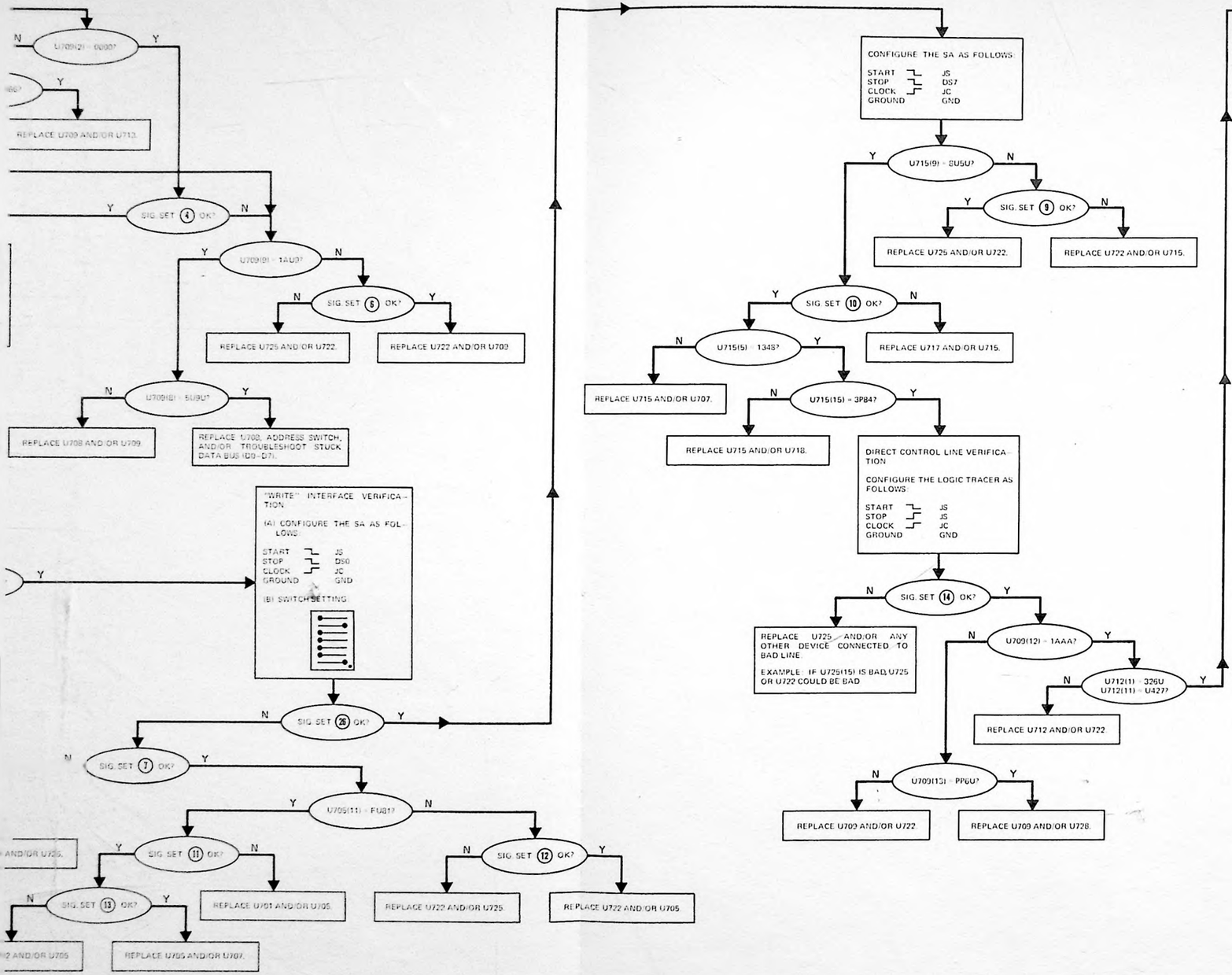


Figure 8-11. HP-IB Troubleshooting Flowchart.

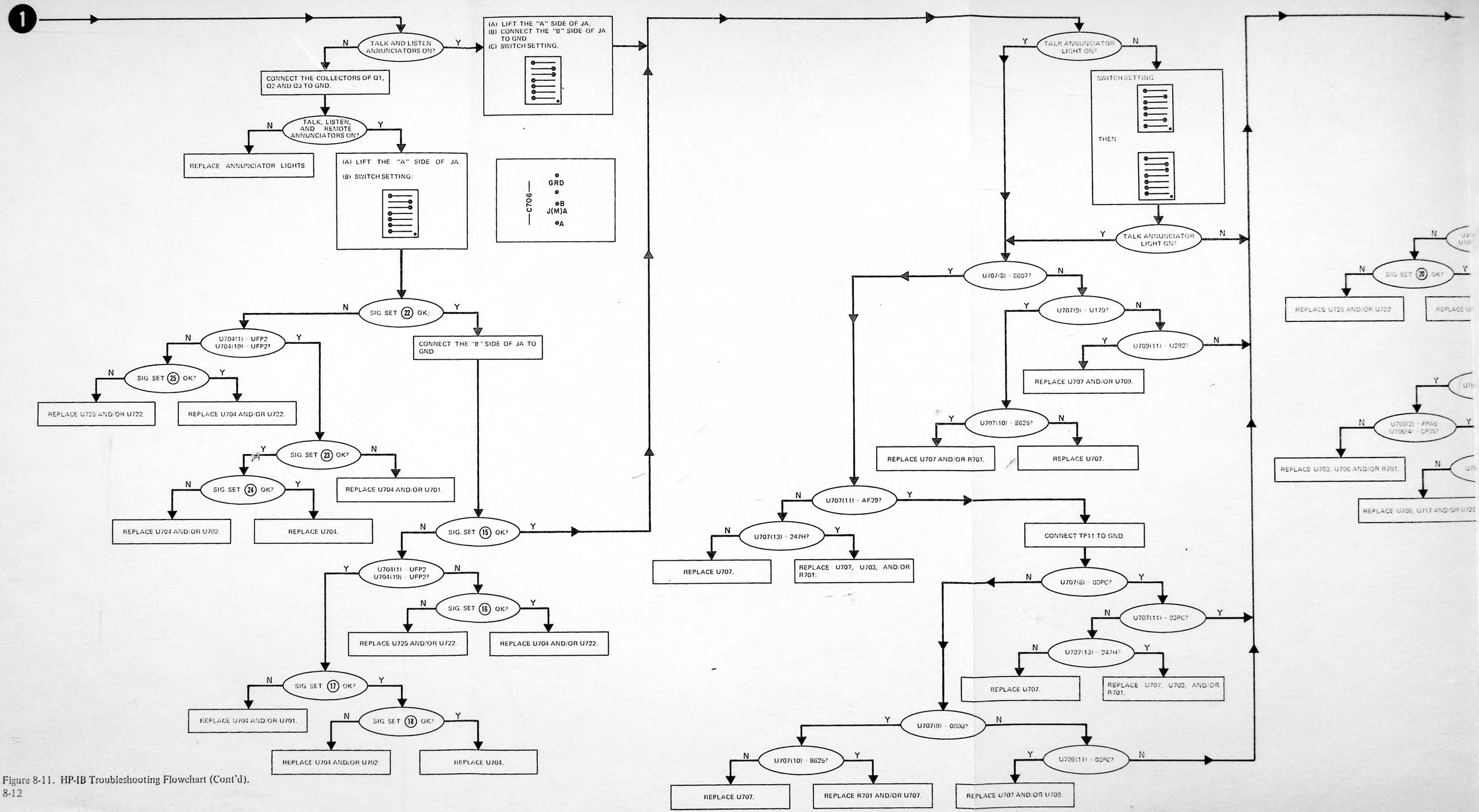
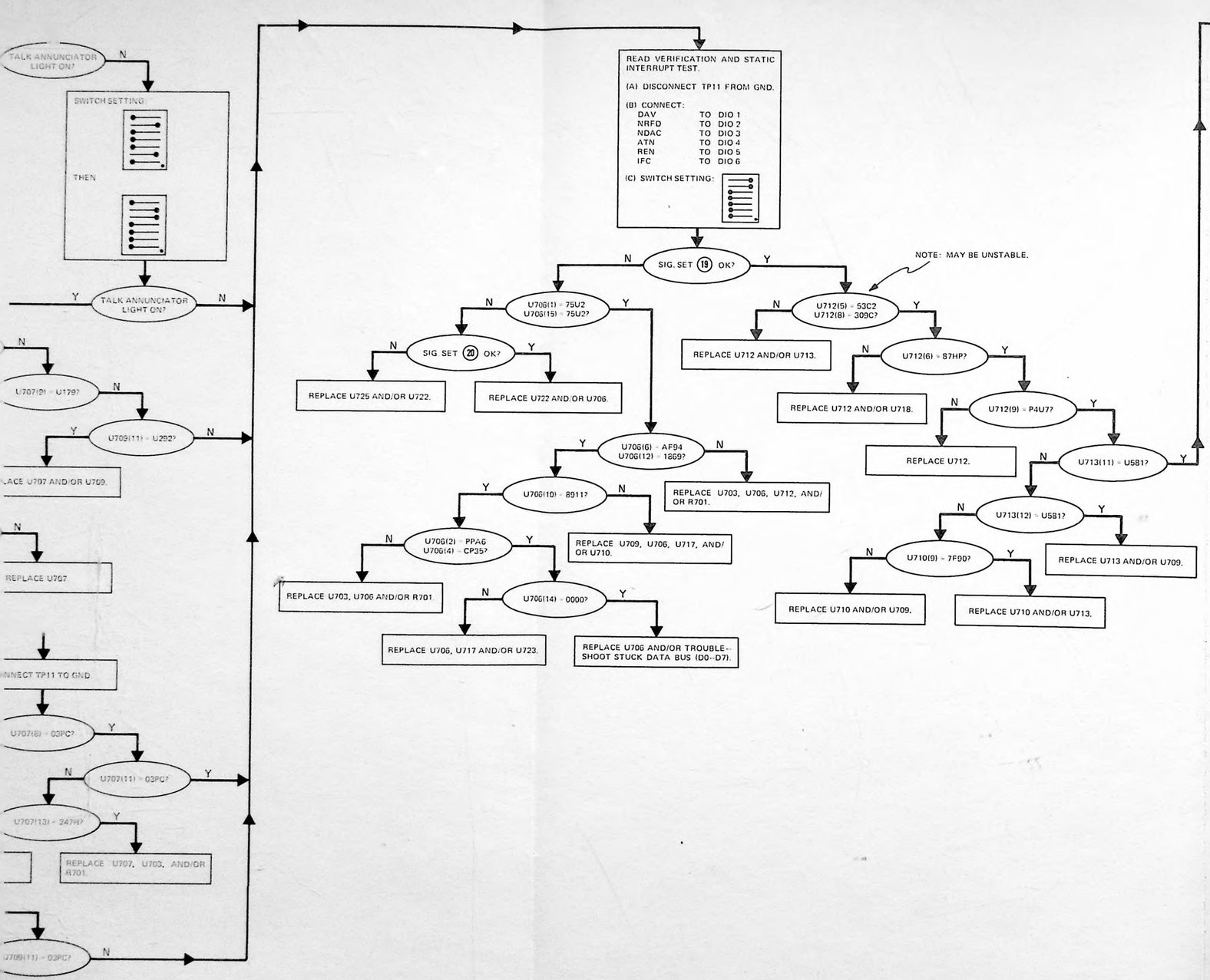


Figure 8-11. HP-IB Troubleshooting Flowchart (Cont'd).



2

HP–IB LOGIC TROUBLESHOOTING

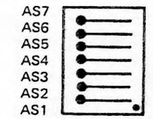
NOTES

Y = YES OR OK
N = NO OR BAD
SA = SIGNATURE ANALYZER

IF THE GATE ON THE SIGNATURE ANALYZER FAILS TO TRIGGER, TROUBLESHOOT THE DEVICES (THE IC'S) TO WHICH START, STOP, AND CLOCK ARE ATTACHED.

SIG. SET = SA SIGNATURES FOR PARTICULAR DEVICE. REFER TO APRON PAGE.

ADDRESS SWITCHES:



SIGNATURE SETS
(SIGNATURE ANALYZER DISPLAY INDICATION)

(15)

U704

Pin		
	3	427F
	5	7H3C
	7	88P5
	9	9182
	11	08F4
	13	7UFP
	15	7A27
	17	HF30

(16)

U722

Pin		
	1	UFP2
	2	928F
	3	5U7A
	4	6215
	5	0000

(17)

U704

Pin		
	2	CP22
	4	91U6
	6	UHHA
	8	15UH

(18)

U704

Pin		
	12	02AA
	14	A157
	16	1172

(19)

U706

Pin		
	3	781P
	5	2FU5
	7	UFU3
	9	4223
	11	7F3A
	13	40AA

(20)

U722

Pin		
	1	5314
	2	1111
	3	A401
	4	2P82
	5	0000

(22)

U704

Pin		
	3	C4C4
	5	6HAH
	7	F526
	9	CU49
	11	5313
	13	3C23
	15	H255
	17	HF30

(23)

U704

Pin		
	2	0000
	4	0000
	6	0000
	8	0000

(24)

U704

Pin		
	12	000
	14	000
	16	000

(25)

U722

Pin		
	1	UFP2
	2	928F
	3	5U7A
	4	6215
	5	0000

HP–IB LOGIC TROUBLESHOOTING

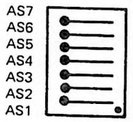
NOTES

Y = YES OR OK
N = NO OR BAD
SA = SIGNATURE ANALYZER

IF THE GATE ON THE SIGNATURE ANALYZER FAILS TO TRIGGER, TROUBLESHOOT THE DEVICES (THE IC'S) TO WHICH START, STOP, AND CLOCK ARE ATTACHED.

SIG. SET = SA SIGNATURES FOR PARTICULAR DEVICE. REFER TO APRON PAGE.

ADDRESS SWITCHES:



SIGNATURE SETS
(SIGNATURE ANALYZER DISPLAY INDICATION)

(15)

U704

Pin		
	3	427F
	5	7H3C
	7	88P5
	9	9182
	11	08F4
	13	7UFP
	15	7A27
	17	HF30

(16)

U722

Pin		
	1	UFP2
	2	928F
	3	5U7A
	4	6215
	5	0000

(17)

U704

Pin		
	2	CP22
	4	91U6
	6	UHHA
	8	15UH

(18)

U704

Pin		
	12	02AA
	14	A157
	16	1172

(19)

U706

Pin		
	3	781P
	5	2FU5
	7	UFU3
	9	4223
	11	7F3A
	13	40AA

(20)

U722

Pin		
	1	5314
	2	1111
	3	A401
	4	2P82
	5	0000

(22)

U704

Pin		
	3	C4C4
	5	6HAH
	7	F526
	9	CU49
	11	5313
	13	3C23
	15	H255
	17	HF30

(23)

U704

Pin		
	2	0000
	4	0000
	6	0000
	8	0000

(24)

U704

Pin		
	12	000
	14	000
	16	000

(25)

U722

Pin		
	1	UFP2
	2	928F
	3	5U7A
	4	6215
	5	0000

HP–IB LOGIC TROUBLESHOOTING

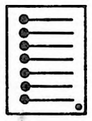
NOTES

Y = YES OR OK
N = NO OR BAD
SA = SIGNATURE ANALYZER

IF THE GATE ON THE SIGNATURE ANALYZER FAILS TO TRIGGER, TROUBLESHOOT THE DEVICES (THE IC'S) TO WHICH START, STOP, AND CLOCK ARE ATTACHED.

SIG. SET = SA SIGNATURES FOR PARTICULAR DEVICE. REFER TO APRON PAGE.

ADDRESS SWITCHES:

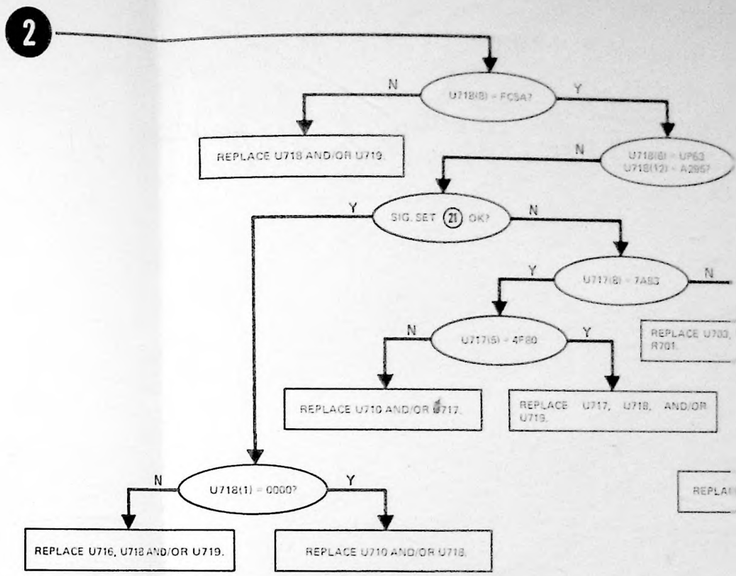


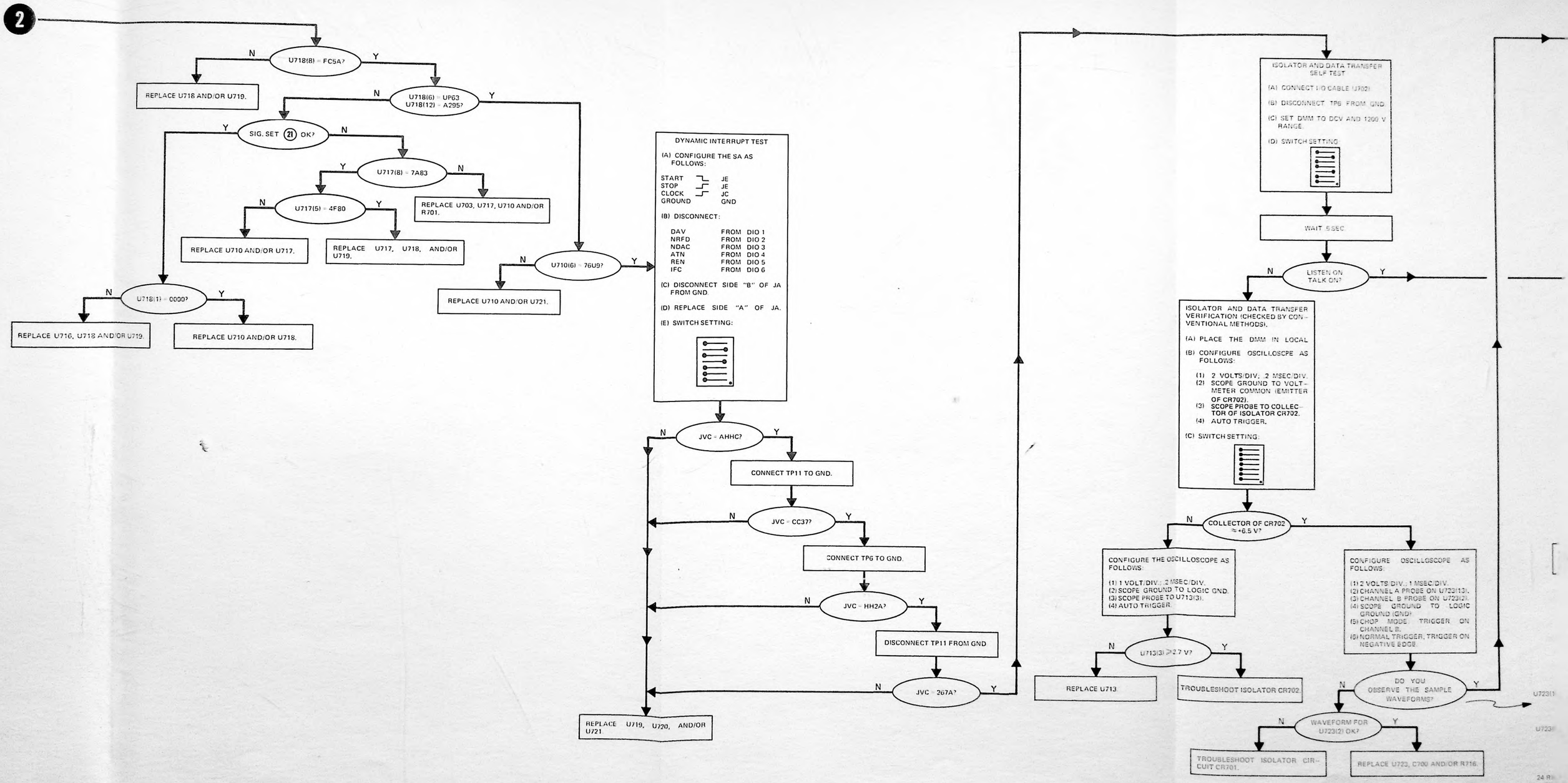
SIGNATURE SETS
(SIGNATURE ANALYZER DISPLAY INDICATION)

(21)

U718

Pin		
	2	76U9
	3	5477
	4	0HA7
	13	7P78




2
U718(8) = FC5A?
N
Y
REPLACE U718 AND/OR U719.
U718(6) = UP63
U718(12) = A295?
N
Y
SIG. SET 21 OK?
Y
N
U717(8) = 7A83
Y
N
U717(5) = 4F80
N
Y
REPLACE U710 AND/OR U717.
REPLACE U717, U718, AND/OR U719.
REPLACE U703, U717, U710 AND/OR R701.
U718(1) = 0000?
N
Y
REPLACE U716, U718 AND/OR U719.
REPLACE U710 AND/OR U718.
U710(6) = 76U9?
N
Y
REPLACE U710 AND/OR U721.
DYNAMIC INTERRUPT TEST
(A) CONFIGURE THE SA AS FOLLOWS:
START JE
STOP JE
CLOCK JC
GROUND GND
(B) DISCONNECT:
DAV FROM DIO 1
NRFD FROM DIO 2
NDAC FROM DIO 3
ATN FROM DIO 4
REN FROM DIO 5
IFC FROM DIO 6
(C) DISCONNECT SIDE "B" OF JA FROM GND.
(D) REPLACE SIDE "A" OF JA.
(E) SWITCH SETTING:
JVC = AHHC?
N
Y
CONNECT TP11 TO GND.
JVC = CC37?
N
Y
CONNECT TP6 TO GND.
JVC = HH2A?
N
Y
DISCONNECT TP11 FROM GND
JVC = 267A?
N
Y
REPLACE U719, U720, AND/OR U721
ISOLATOR AND DATA TRANSFER SELF TEST
(A) CONNECT I/O CABLE U702.
(B) DISCONNECT TP6 FROM GND.
(C) SET DMM TO DCV AND 1200 V RANGE.
(D) SWITCH SETTING:
WAIT 5 SEC
LISTEN ON TALK ON?
N
Y
ISOLATOR AND DATA TRANSFER VERIFICATION (CHECKED BY CONVENTIONAL METHODS).
(A) PLACE THE DMM IN LOCAL
(B) CONFIGURE OSCILLOSCPE AS FOLLOWS:
(1) 2 VOLTS/DIV, 2 MSEC/DIV.
(2) SCOPE GROUND TO VOLTMETER COMMON (EMITTER OF CR702).
(3) SCOPE PROBE TO COLLECTOR OF ISOLATOR CR702.
(4) AUTO TRIGGER.
(C) SWITCH SETTING:
COLLECTOR OF CR702 ≈+6.5 V?
N
Y
CONFIGURE THE OSCILLOSCOPE AS FOLLOWS:
(1) 1 VOLT/DIV., 2 MSEC/DIV.
(2) SCOPE GROUND TO LOGIC GND.
(3) SCOPE PROBE TO U713(3).
(4) AUTO TRIGGER.
U713(3) ≥2.7 V?
N
Y
REPLACE U713.
TROUBLESHOOT ISOLATOR CR702.
CONFIGURE OSCILLOSCOPE AS FOLLOWS:
(1) 2 VOLTS/DIV., 1 MSEC/DIV.
(2) CHANNEL A PROBE ON U723(13).
(3) CHANNEL B PROBE ON U723(2).
(4) SCOPE GROUND TO LOGIC GROUND (GND)
(5) CHOP MODE, TRIGGER ON CHANNEL B.
(6) NORMAL TRIGGER, TRIGGER ON NEGATIVE EDGE.
DO YOU OBSERVE THE SAMPLE WAVEFORMS?
N
Y
WAVEFORM FOR U723(2) OK?
N
Y
TROUBLESHOOT ISOLATOR CIRCUIT CR701.
REPLACE U723, C700 AND/OR R716.

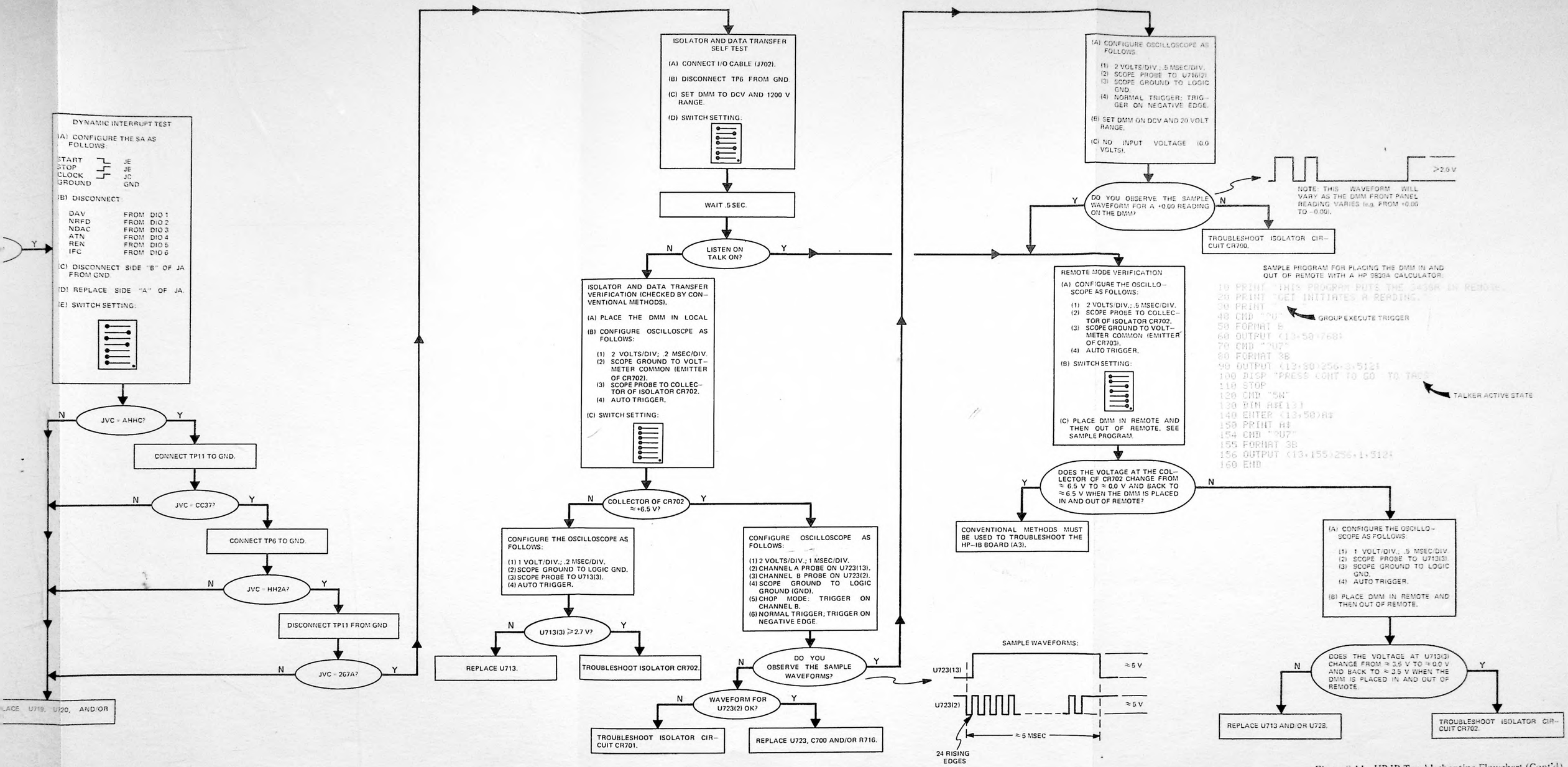


Figure 8-11. HP-IB Troubleshooting Flowchart (Cont'd).

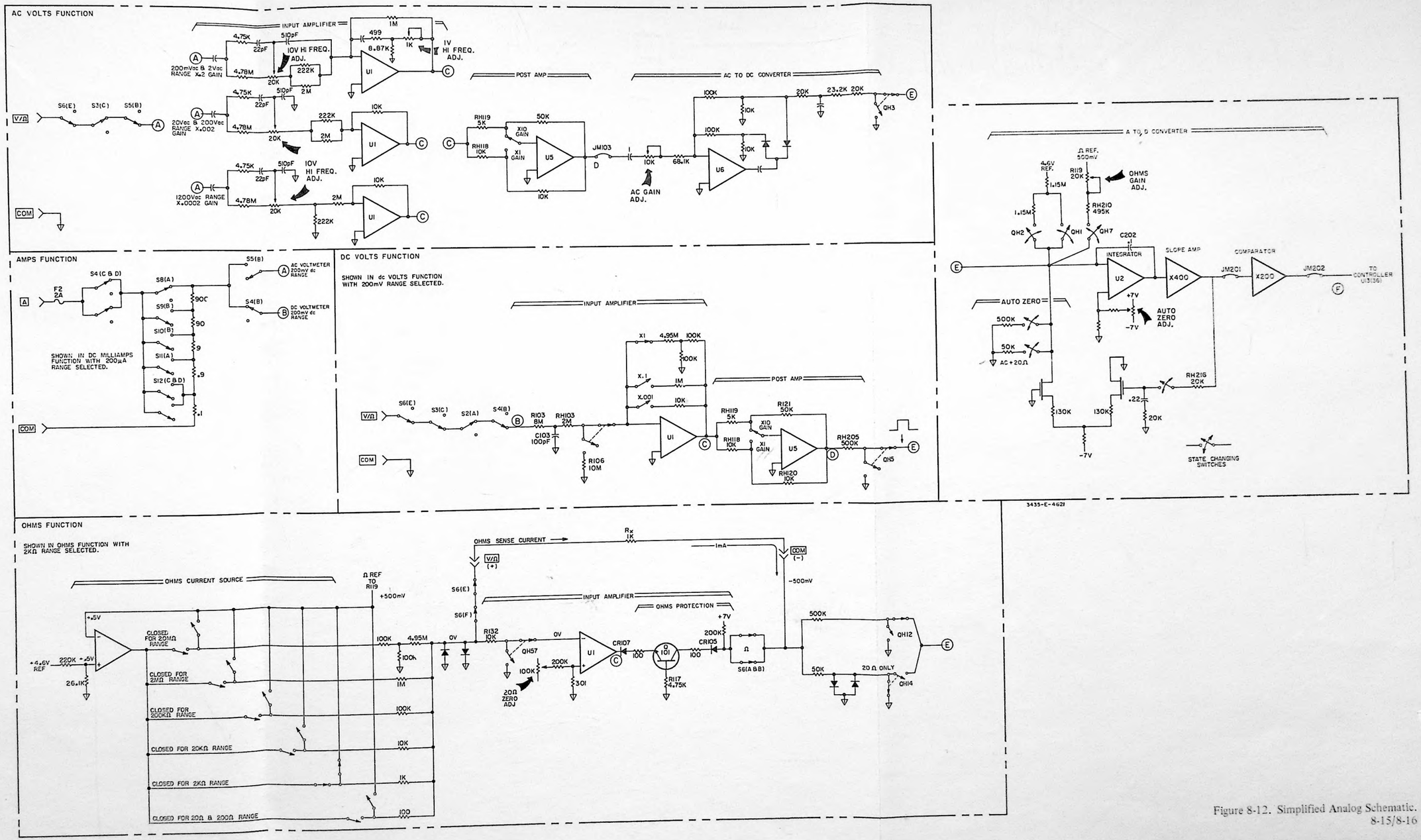
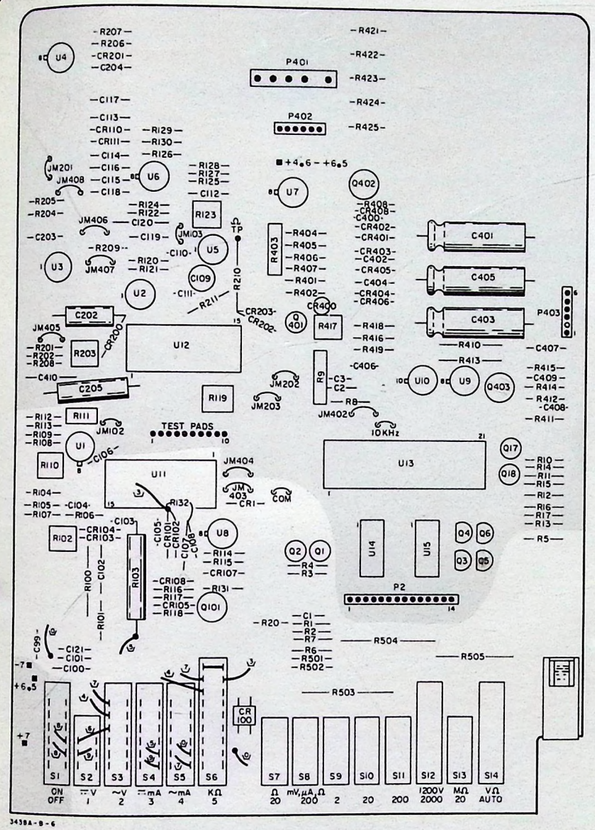


Figure 8-12. Simplified Analog Schematic.
8-15/8-16



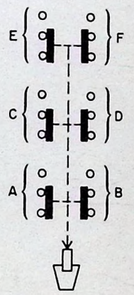
A1
03438-66501

NOTE 1

THE SCHEMATIC IS SHOWN WITH DCV (FUNCTION) AND .2 V (RANGE) SELECTED. PROMINANT SCHEMATIC LINES SHOW THE SIGNAL PATH FOR THIS SWITCH SETTING.

NOTE 2

SWITCHES S2 THROUGH S14 ARE SCHEMATICALLY ORIENTED IN ASCENDING NUMERICAL ORDER FROM LEFT TO RIGHT. THIS ORIENTATION IS THE SAME AS THE PHYSICAL ORIENTATION OF THE ACTUAL SWITCHES AS THEY ARE VIEWED ON THE COMPONENT LOCATOR ON THIS PAGE. SWITCH SECTIONS ARE LABELED A THROUGH F ON THE SCHEMATIC AS SHOWN IN THE DIAGRAM BELOW:



NOTE 3

U11, U12, AND U13 ARE HYBRID INTEGRATED CIRCUITS. FINE LINE RESISTORS AND MOS FET SWITCHES WHICH ARE PART OF THE HYBRIDS ARE SHOWN ON THE SCHEMATIC FOR OPERATIONAL CLARIFICATION ONLY. THESE COMPONENTS ARE NOT INDIVIDUALLY SERVICEABLE.

NOTE 4

SIMPLIFIED SCHEMATIC REPRESENTATIONS OF MOS FET SWITCHES ARE USED FOR SCHEMATIC CLARITY. COMPARISONS OF THE SIMPLIFIED, ACTUAL AND FUNCTIONAL SCHEMATIC REPRESENTATIONS ARE AS FOLLOWS:

	SIMPLIFIED	ACTUAL	FUNCTIONAL
SINGLE MOS FET SWITCH			
DUAL MOS FET SWITCH			

RANGE	CODE			
	MRD	MRE	MRF	AUTO
20 Ω (S7)	0	1	0	1
200 (S8)	0	0	0	1
2 (S9)	1	0	0	1
20 (S10)	1	1	0	1
200 (S11)	1	1	1	1
2000 (S12)	0	1	1	1
20 MΩ (S13)	0	0	1	1
AUTO/MANUAL (S14)	OPEN	OPEN	OPEN	0

1 = +7 V
0 = 0 V (⏚)
MRD = MANUAL RANGE LINE "D"
FNA = FUNCTION LINE "A"

FUNCTION	CODE		
	FNA	FNB	FNC
DCV (S2)	1	1	0
ACV (S3)	1	0	1
DCI (S4)	1	0	0
ACI (S5)	0	0	0
Ω (S6)	1	1	1

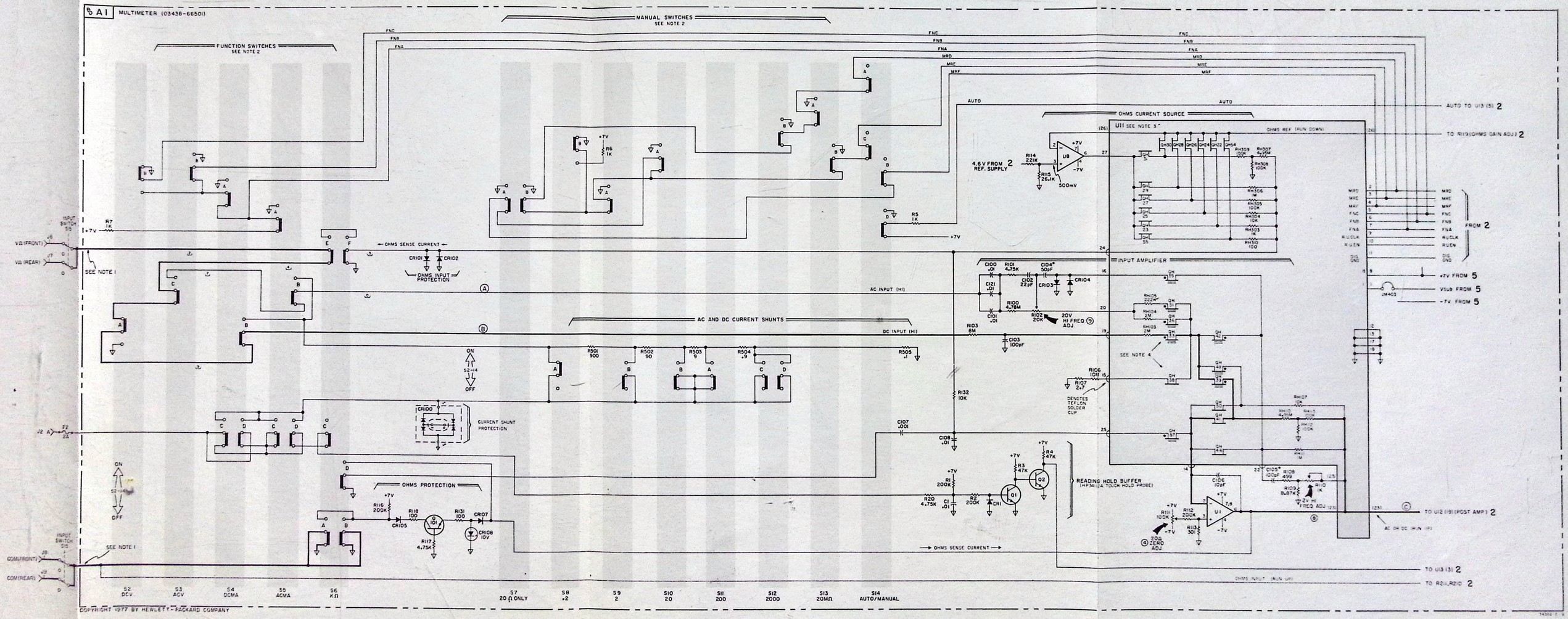
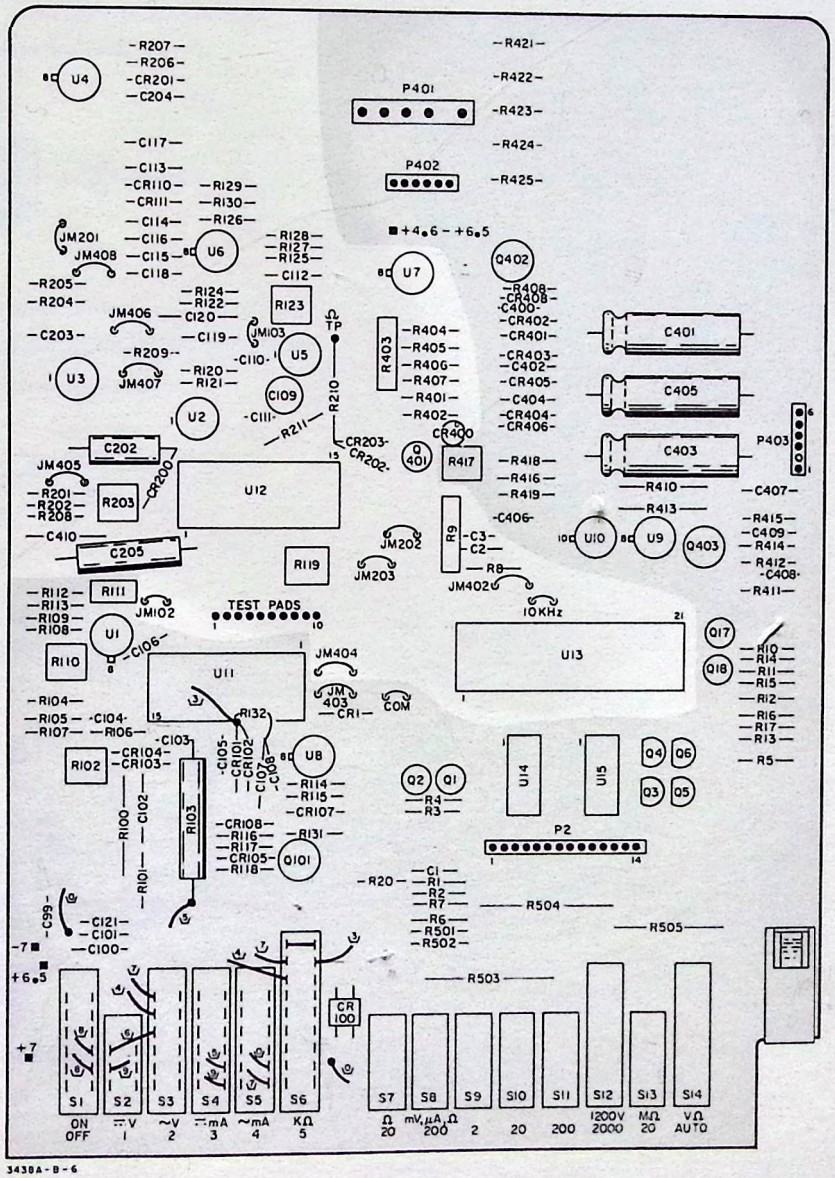


Figure 8-13. 3438A Input Switching, Input Amplifier, and Ohms Current Source Schematic.
8-17/8-18



3438A-B-6

AI

03438-66501

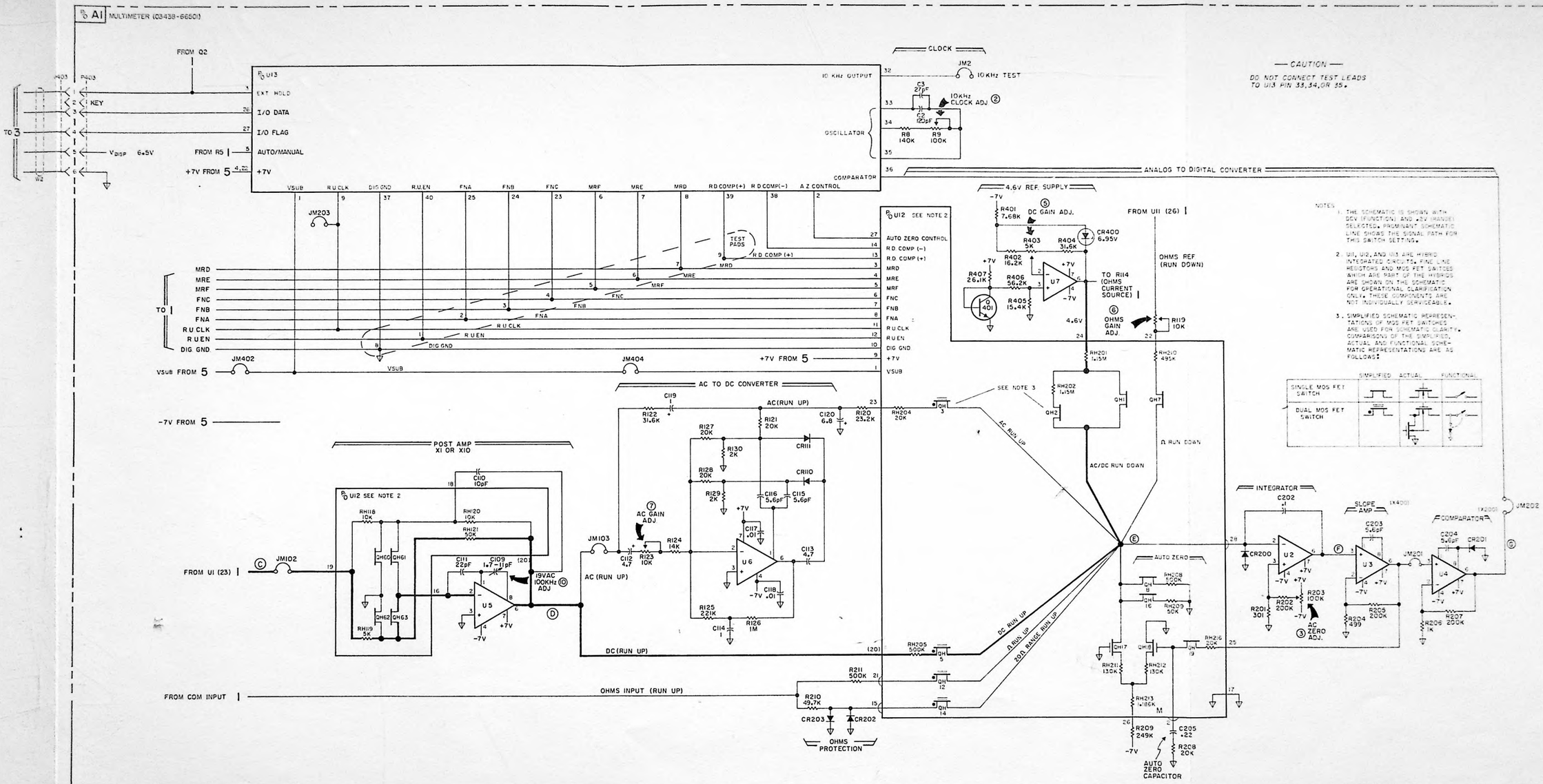
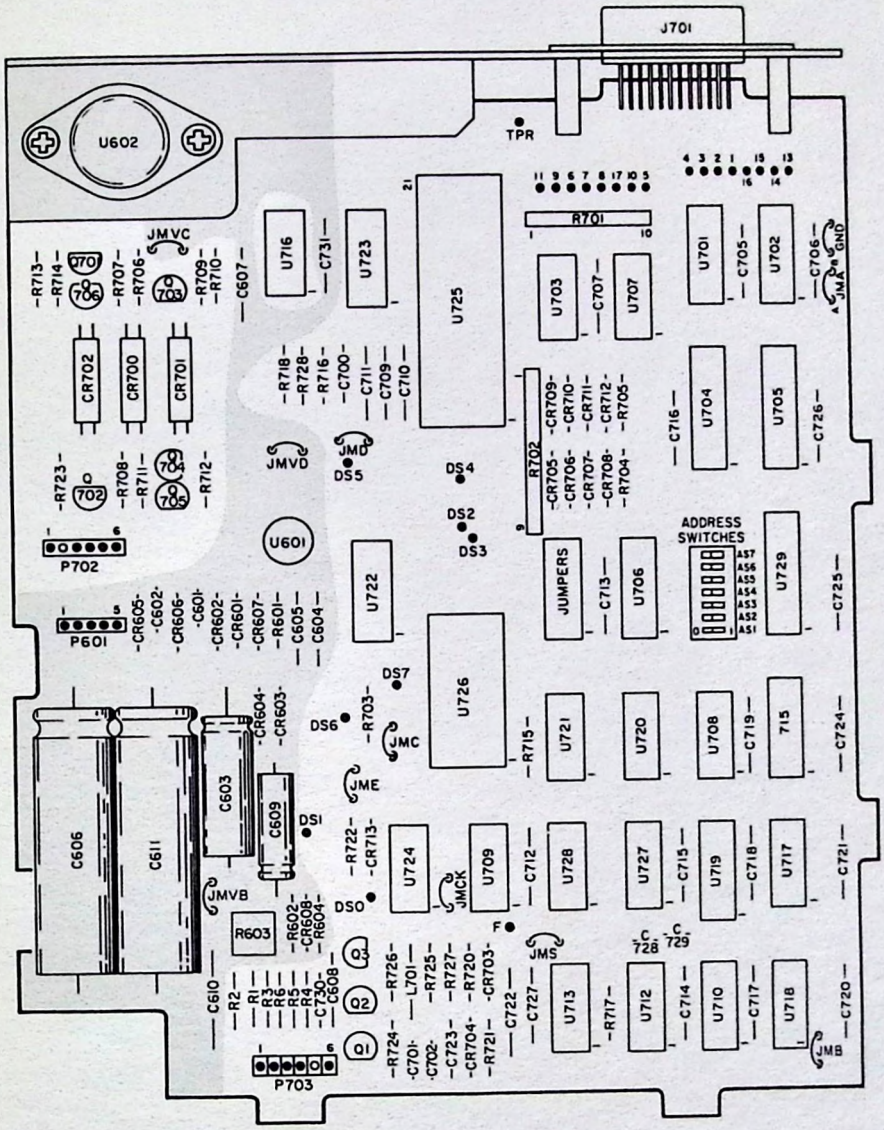
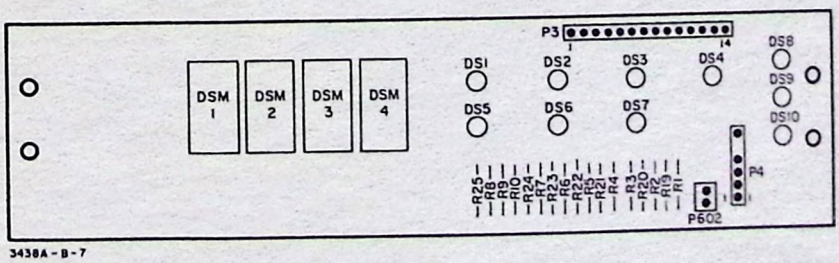


Figure 8-14. 3438A Post Amplifier, AC to DC Converter and Analog to Digital



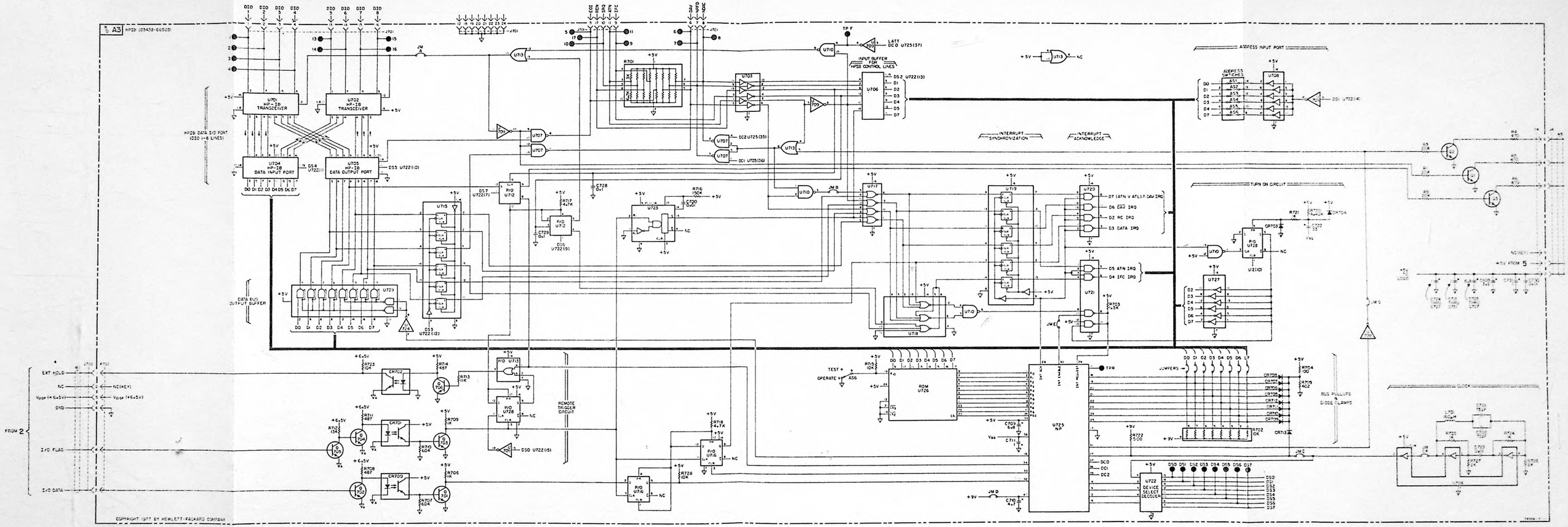
A3
03438-66503

3438A-B-8



A2
03438-66502

3438A-B-7


A3 HPIB (03438-66503)
HPIB DATA I/O PORT (DIO 1-8 LINES)
U701 HP-IB TRANSCEIVER
U702 HP-IB TRANSCEIVER
U704 HP-IB DATA INPUT PORT
U705 HP-IB DATA OUTPUT PORT
DATA BUS OUTPUT BUFFER
INPUT BUFFER FOR HPIB CONTROL LINES
INTERRUPT SYNCHRONIZATION
INTERRUPT ACKNOWLEDGE
ADDRESS INPUT PORT
ADDRESS SWITCHES
TURN ON CIRCUIT
REMOTE TRIGGER CIRCUIT
ROM U726
U725 NP
DEVICE SELECT DECODER
BUS PULLUPS & DIODE LAMPS
CLOCK
JUMPERS
FROM 2
EXT HOLD
I/O FLAG
I/O DATA
COPYRIGHT 1977 BY HEWLETT-PACKARD COMPANY

Figur

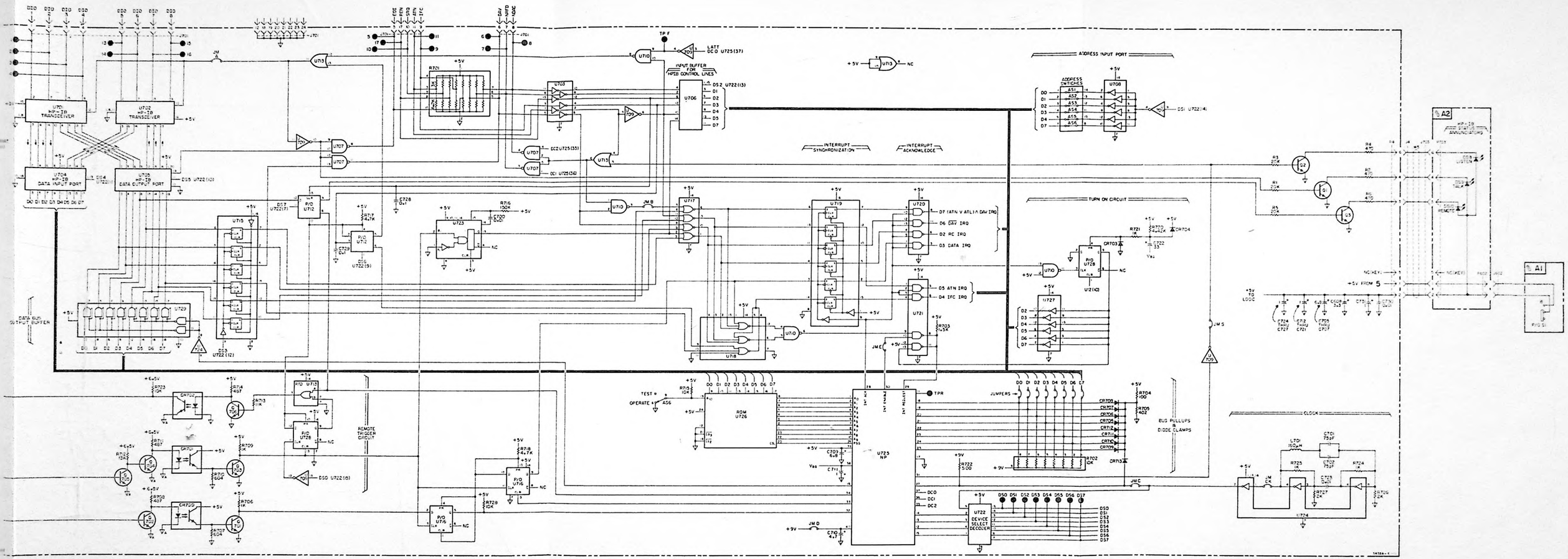
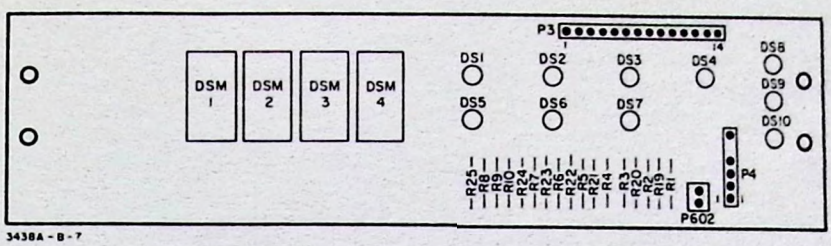
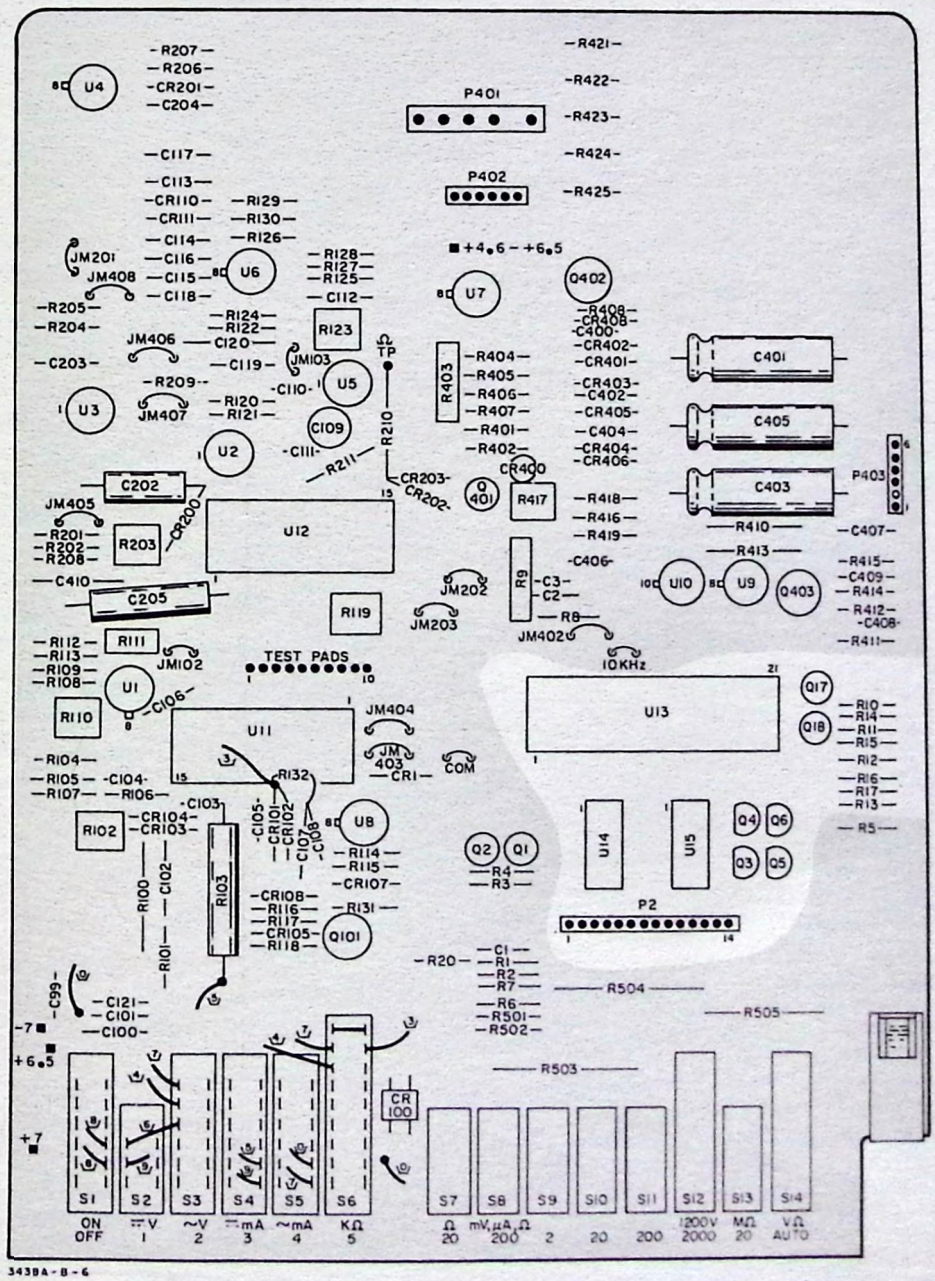


Figure 8-15. 3438A HP-IB Schematic.
8-21/8-22



A2

03438-66502



A1

03438-66501

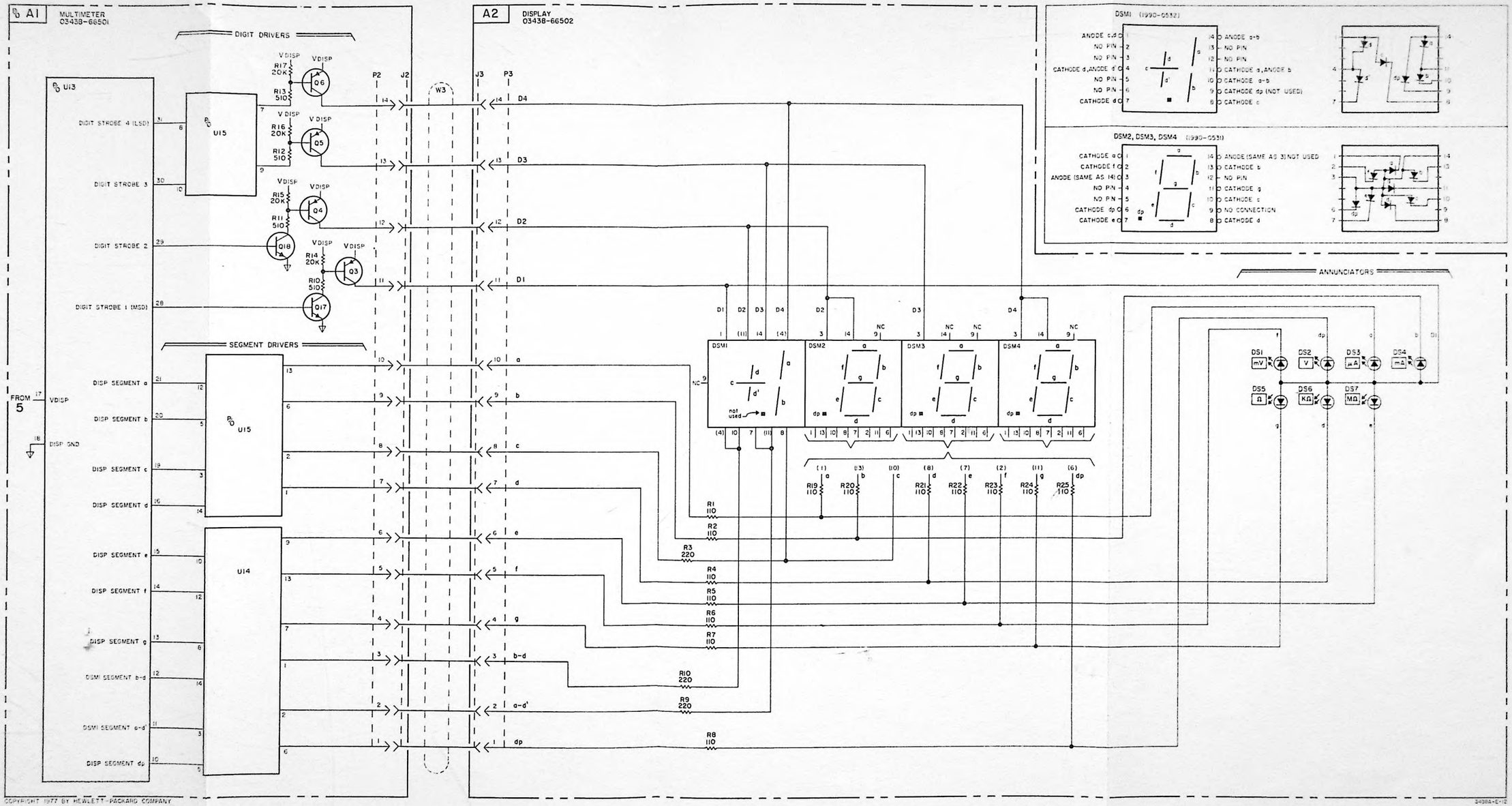
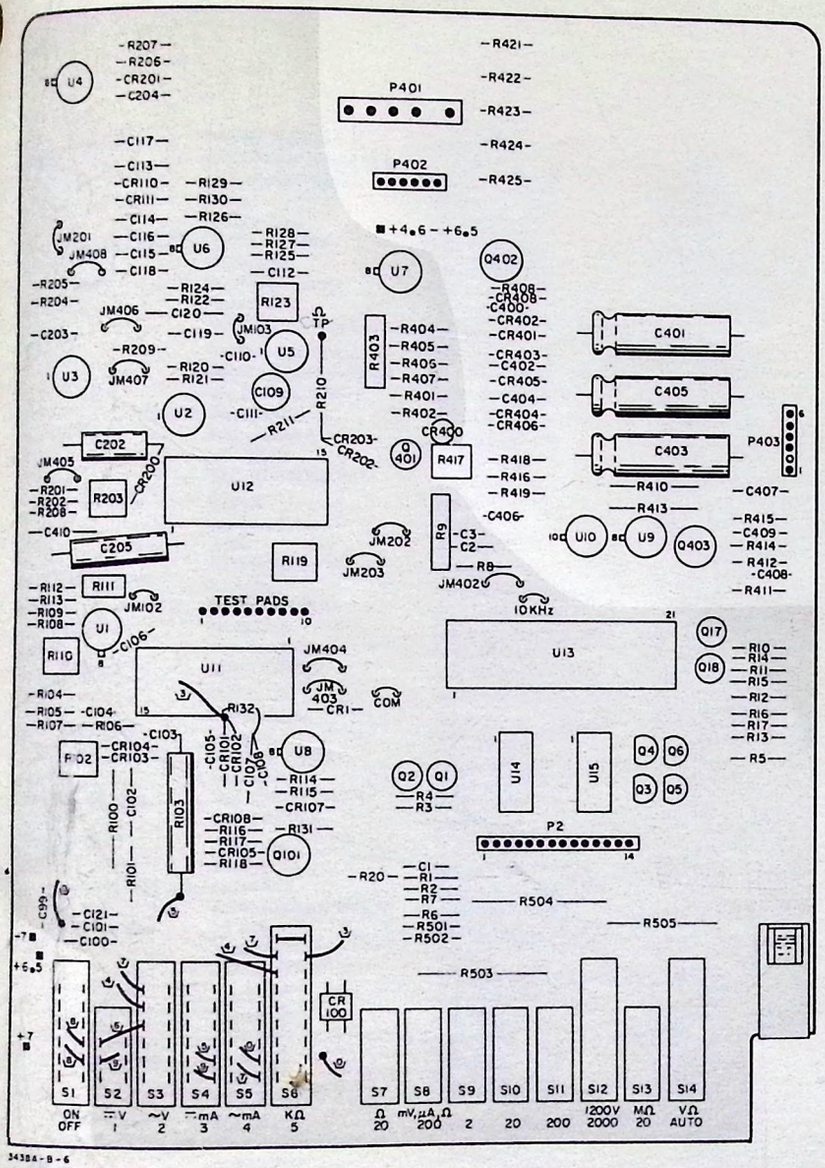
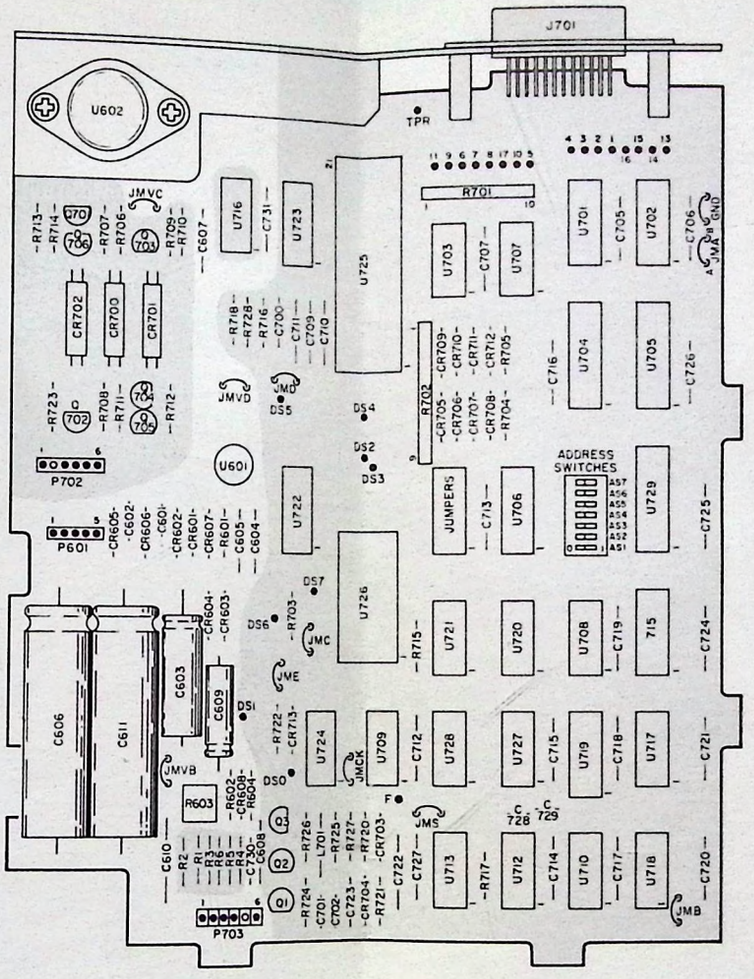


Figure 8-16. 3438A Display Schematic.
8-23/8-24



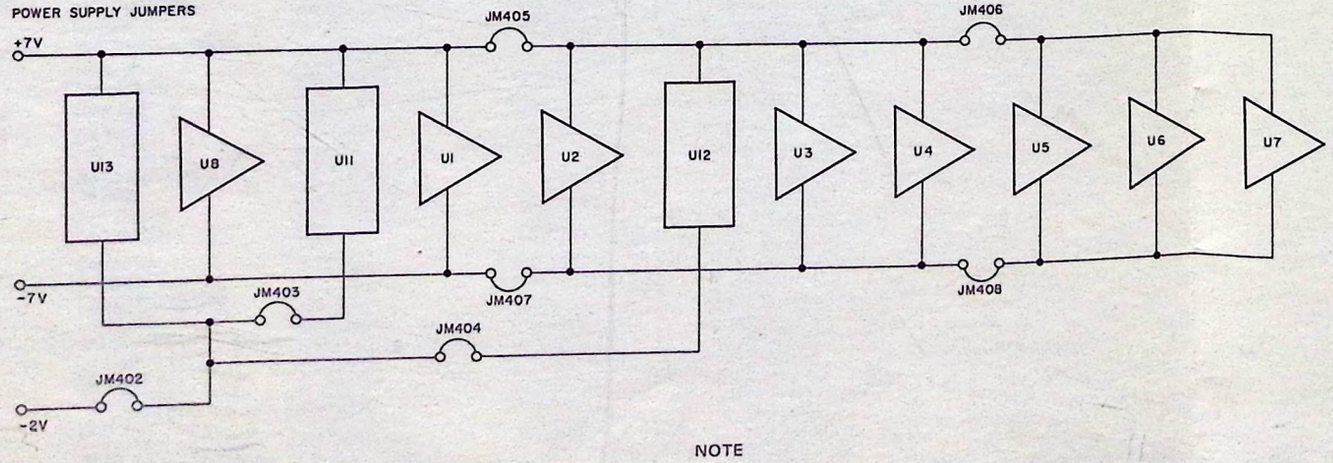
3438A-B-6

A1
03438-66501



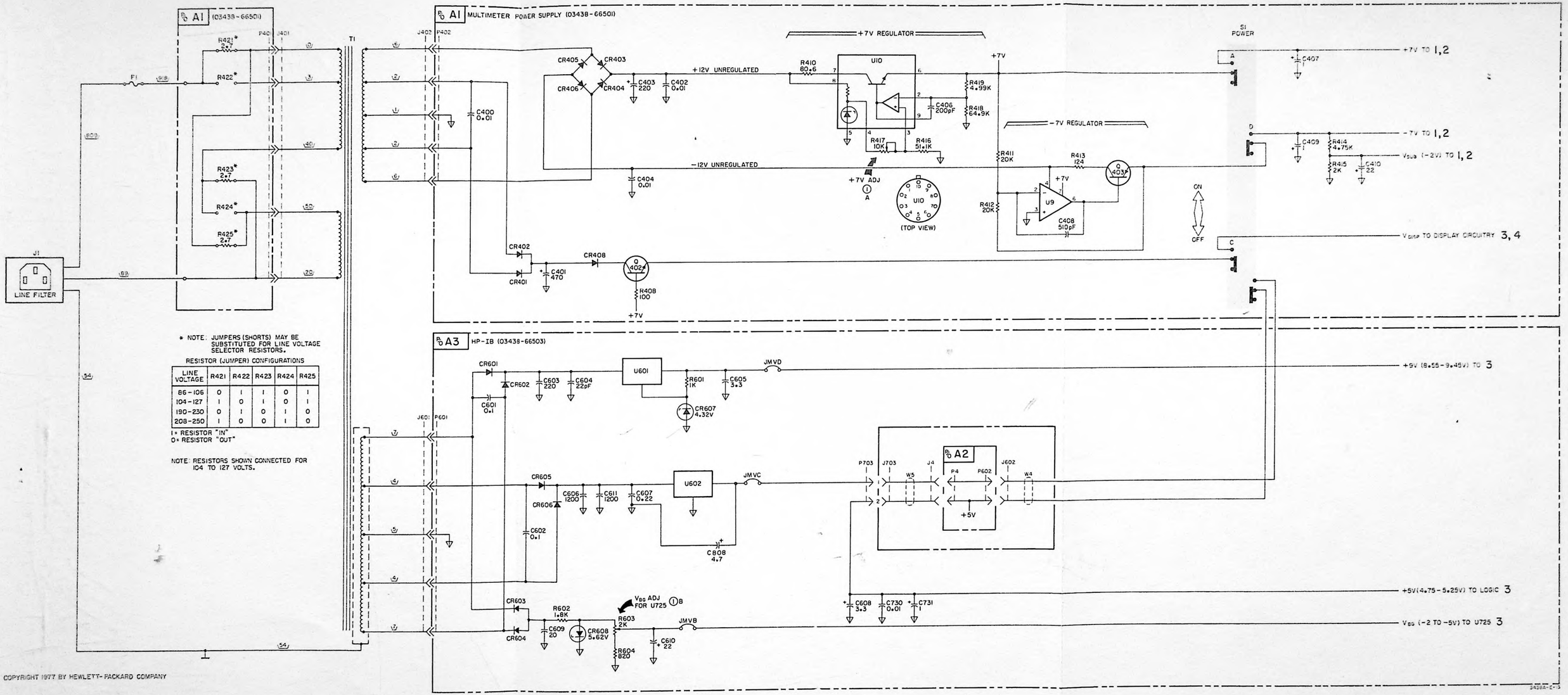
3438A-B-8

A3
03438-66503



NOTE

JM 405 THROUGH JM 408 ARE NOT SHOWN ON THE SCHEMATIC DIAGRAMS.



5

Figure 8-17. Power Supply Schematic.
8-25/8-26

AFRICA, ASIA, AUSTRALIA

ANGOLA
Telectra
Empresa Técnica de Equipamentos Eléctricos, S.A.R.L.
R. Barbosa Rodrigues, 41-1°DT.°
Caixa Postal, 6487
Luanda
Tel: 35515/6
Cable: TELECTRA Luanda

AUSTRALIA
Hewlett-Packard Australia Pty. Ltd.
31-41 Joseph Street
Blackburn, Victoria 3130
P.O. Box 36
Doncaster East,
Victoria 3109
Tel: 696351
Telex: 31-024
Cable: HEWPARD Melbourne

Hewlett-Packard Australia Pty. Ltd.
31 Bridge Street
Pymble
New South Wales, 2073
Tel: 4496566
Telex: 21561
Cable: HEWPARD Sydney

Hewlett-Packard Australia Pty. Ltd.
153 Greenhill Road
Parkside, S.A., 5063
Tel: 2725911
Telex: 82536
Cable: HEWPARD Adelaide

Hewlett-Packard Australia Pty. Ltd.
141 Stirling Highway
Nedlands, W.A. 6009
Tel: 3865455
Telex: 93859
Cable: HEWPARD Perth

Hewlett-Packard Australia Pty. Ltd.
121 Wollongong Street
Fyshwick, A.C.T. 2609
Tel: 804244
Telex: 62650
Cable: HEWPARD Canberra

Hewlett Packard Australia Pty. Ltd.
5th Floor
Teachers Union Building
495-499 Boundary Street
Spring Hill, Queensland 4000
Tel: 2291544
Cable: HEWPARD Brisbane

BANGLADESH
The General Electric Co. of Bangladesh Ltd.
Magnet House 72
Dilkusha Commercial Area
Motijheil, Dacca 2
Tel: 252415, 252419
Telex: 734
Cable: GECDAC Dacca

ETHIOPIA
Abdella Abdulmalik
P.O. Box 2635
Addis Ababa
Tel: 11 93 40

GUAM
Guam Medical Supply, Inc.
Suite C, Airport Plaza
P.O. Box 8947
Tamuning 96911
Tel: 646-4513
Cable: EARMED Guam

HONG KONG
Hewlett-Packard Hong Kong Ltd.
Room 105, Austin Centre
1st Floor
21 Austin Avenue
TST P.O. Box 98524
Kowloon
Tel: 3-697446 (5 lines)
Telex: 36678 HX
Cable: HEWPACK Hong Kong

Medical/Analytical Only
Schmidt & Co. (Hong Kong) Ltd.
Wing On Centre, 28th Floor
Connaught Road, C.
Hong Kong
Tel: 5-455644
Telex: 74766 SCHMX HX

INDIA
Blue Star Ltd.
Sahas
414/2 Vir Savarkar Marg
Prabhadevi
Bombay 400 025
Tel: 45 78 87
Telex: 011-4093
Cable: FROSTBLUE

Blue Star Ltd.
Band Box House
Prabhadevi
Bombay 400 025
Tel: 45 73 01
Telex: 011-3751
Cable: BLUESTAR

Blue Star Ltd.
Bhavdeep
Stadium Road
Ahmedabad 380 014
Tel: 43922
Telex: 012-234
Cable: BLUEFROST

Blue Star Ltd.
7 Hare Street
Calcutta 700 001
Tel: 23-0131
Telex: 021-7655
Cable: BLUESTAR

Blue Star Ltd.
Bhandari House
91 Nehru Place
New Delhi 110 024
Tel: 682547
Telex: 031-2463
Cable: BLUESTAR

Blue Star Ltd.
T.C. 7/603 'Poornima
Maruthankuzhi
Trivandrum 695 013
Tel: 65799
Telex: 0884-259
Cable: BLUESTAR

Blue Star Ltd.
11 Magarath Road
Bangalore 560 025
Tel: 55668
Telex: 0845-430
Cable: BLUESTAR

Blue Star Ltd.
Meeakshi Mandiram
XXXXV/1379-2 Mahatma Gandhi Rd.
Cochin 682 016
Tel: 32069
Telex: 085-514
Cable: BLUESTAR

Blue Star Ltd.
1-1-117/1 Sarojini Devi Road
Secunderabad 500 033
Tel: 70126
Telex: 0155-459
Cable: BLUESTAR

Blue Star Ltd.
133 Kodambakkam High Road
Madras 600 034
Tel: 82057
Telex: 041-379
Cable: BLUESTAR

INDONESIA
BERCA Indonesia P.T.
P.O. Box 496/Jkt.
Jln. Abdul Muis 62
Jakarta
Tel: 349255, 349886
Telex: 46748 BERSIL IA
Cable: BERSAL

BERCA Indonesia P.T.
P.O. Box 174/Sby.
23 Jln. Jimerto
Surabaya
Tel: 42027
Cable: BERCACON

JAPAN
Yokogawa-Hewlett-Packard Ltd.
29-21, Takaido-Higashi 3-chome
Suginami-ku, **Tokyo** 168
Tel: 03-331-6111
Telex: 232-2024 YHP-Tokyo
Cable: YHPMARKET TOK 23 724

Yokogawa-Hewlett-Packard Ltd.
Chuo Bldg., 4th Floor
4-20, Nishinakajima 5-chome
Yodogawa-ku, Osaka-shi
Osaka, 532
Tel: 06-304-6021
Telex: 523-3624

Yokogawa-Hewlett-Packard Ltd.
Sunitomo Seimei Nagaya Bldg.
11-2 Shimosasajima-cho,
Nakamura-ku, **Nagoya,** 450
Tel: 052 571-5171

Yokogawa-Hewlett-Packard Ltd
Tanigawa Building
2-24-1 Tsuruya-cho
Kanagawa-ku
Yokohama, 221
Tel: 045-312-1252
Telex: 382-3204 YHP YOK

Yokogawa-Hewlett-Packard Ltd.
Mito Mitsui Building
105, 1-chome, San-no-maru
Mito, Ibaragi 310
Tel: 0292-25-7470

Yokogawa-Hewlett-Packard Ltd.
Inoue Building
1348-3, Asahi-cho, 1-chome
Atsugi, Kanagawa 243
Tel: 0462-24-0452

Yokogawa-Hewlett-Packard Ltd.
Kumagaya Asahi
Hachijuni Building
4th Floor
3-4, Tsukuba
Kumagaya, Saitama 360
Tel: 0485-24-6563

KENYA
ADCOM Ltd., Inc.
P.O. Box 30070
Nairobi
Tel: 331955
Telex: 22639

Medical Only
International Aeradio (E.A.) Ltd.
P.O. Box 19012
Nairobi Airport
Nairobi
Tel: 336055/56
Telex: 22201/22301
Cable: INTAERIO Nairobi

Medical Only
International Aeradio (E.A.) Ltd.
P.O. Box 95221
Mombasa

KOREA
Samsung Electronics Co., Ltd.
22nd Floor Dongbang Bldg.,
250, 2-KA, Taepyung-Ro
Chung-Ku,
Seoul
Tel: 777-4886
Telex: SAMSAN 27364

MALAYSIA
Hewlett-Packard Sales (Malaysia) Sdn. Bhd.
Suite 2.21/2.22
Bangunan Angkasa Raya
Jalan Ampang
Kuala Lumpur
Tel: 483680, 485653

Protel Engineering
P.O. Box 1917
Lot 259, Satok Road
Kuching, **Sarawak**
Tel: 53544
Cable: PROTELENG

MOZAMBIQUE
A.N. Goncalves, Ltd.
162, 1° Apt. 14 Av. D. Luis
Caixa Postal 107
Maputo
Tel: 27091, 27114
Telex: 6-203 NEGON Mo
Cable: NEGON

NEW GUINEA
Hewlett-Packard Australia Pty. Ltd.
Development Bank Building
Ground Floor
Ward Strip
Port Moresby, Papua
Tel: 258933

NEW ZEALAND
Hewlett-Packard (N.Z.) Ltd.
4-12 Cruickshank Street
Kilbirnie, Wellington 3
P.O. Box 9443
Courtney Place
Wellington
Tel: 877-199
Cable: HEWPACK Wellington

Hewlett-Packard (N.Z.) Ltd.
P.O. Box 26-189
169 Manukau Road
Epsom, **Auckland**
Tel: 687-159
Cable: HEWPACK Auckland

Analytical/Medical Only
Northrop Instruments & Systems Ltd.,
Sturdee House
85-87 Ghuznee Street
P.O. Box 2406
Wellington
Tel: 850-091
Telex: NZ 31291

Northrup Instruments & Systems Ltd
Eden House, 44 Khyber Pass Rd.
P.O. Box 9682, Newmarket
Auckland 1
Tel: 794-091

Northrup Instruments & Systems Ltd
Terrace House, 4 Oxford Terrace
P.O. Box 8388
Christchurch
Tel: 64-165

NIGERIA
The Electronics Instrumentations Ltd.
N68/770 Oyo Road
Oluseun House
P.M.B. 5402
Ibadan
Tel: 461577
Telex: 31231 TEIL NG
Cable: THETIEL Ibadan

The Electronics Instrumentations Ltd.
144 Agege Motor Road, Mushin
P.O. Box 481
Mushin, **Lagos**
Cable: THETEIL Lagos

PAKISTAN
Mushko & Company Ltd.
Oosman Chambers
Abdullah Haroon Road
Karachi-3
Tel: 511027, 512927
Telex: 2894
Cable: COOPERATOR Karachi

Mushko & Company, Ltd.
10, Bazar Rd.
Sector G-6/4
Islamabad
Tel: 28264
Cable: FEMUS Rawalpindi

PHILIPPINES
The Online Advanced Systems Corporation
Rico House
Amorsolo cor. Herrera Str.
Legaspi Village, Makati
P.O. Box 1510
Metro **Manila**
Tel: 85-35-81, 85-34-91, 85-32-21
Telex: 3274 ONLINE

RHODESIA
Field Technical Sales
45 Kelvin Road North
P.O. Box 3458
Salisbury
Tel: 705231 (5 lines)
Telex: RH 4122

SINGAPORE
Hewlett-Packard Singapore (Pte.) Ltd.
1150 Depot Road
P.O. Box 58
Alexandra Post Office
Singapore 3
Tel: 270-2355
Telex: HPSG RS 21486
Cable: HEWPACK, Singapore

SOUTH AFRICA
Hewlett-Packard South Africa (Pty.) Ltd.
Private Bag Wendywood,
Sandton, Transvaal, 2144
Hewlett-Packard Centre
Daphne Street, Wendywood,
Sandton, 2144
Tel: 802-5111/25
Telex: 8-4782
Cable: HEWPACK Johannesburg

Hewlett-Packard South Africa (Pty.) Ltd.
P.O. Box 120
Howard Place,
Cape Province, 7450
Pine Park Centre, Forest Drive,
Pinelands,
Cape Province, 7405
Tel: 53-7955 thru 9
Telex: 57-0006

SRI LANKA
Metropolitan Agencies Ltd.
209 9 Union Place
Colombo 2
Tel: 35647
Telex: 1377METROLTD CE
Cable: METROLTD

SUDAN
Radison Trade
P.O. Box 921
Khartoum
Tel: 44048
Telex: 375

TAIWAN
Hewlett-Packard Far East Ltd.
Taiwan Branch
Bank Tower, 5th Floor
205 Tun Hau North Road
Taipei
Tel: (02) 751-0404 (15 lines)
Cable: HEWPACK TAIPEI

Hewlett-Packard Far East Ltd.
Taiwan Branch
68-2, Chung Cheng 3rd. Road
Kaohsiung
Tel: (07) 242318-Kaohsiung

Analytical Only
San Kwang Instruments Co., Ltd.
20 Yung Sui Road
Taipei
Tel: 3615446-9 (4 lines)
Telex: 22894 SANKWANG
Cable: SANKWANG Taipei

TANZANIA
Medical Only
International Aeradio (E.A.), Ltd.
P.O. Box 861
Dar es Salaam
Tel: 21251 Ext. 265
Telex: 41030

THAILAND
UNIMESA Co. Ltd.
Elcom Research Building
2538 Sukumvit Ave.
Bangchak, Bangkok
Tel: 3932387, 3930338
Cable: UNIMESA Bangkok

ZAMBIA
R.J. Tilbury (Zambia) Ltd
P.O. Box 2792
Lusaka
Tel: 73793
Cable: ARJAYTEE, Lusaka

OTHER AREAS NOT LISTED, CONTACT:
Hewlett Packard Intercontinental
3495 Deer Creek Road
Palo Alto, California 94304
Tel: (415) 856-1501
TWX: 910-373-1267
Cable: HEWPACK Palo Alto
Telex: 034-8300, 034-8493

SALES OFFICES
(cont.)

CANADA

ALBERTA
Hewlett-Packard (Canada) Ltd.
11620A - 168th Street
Edmonton T5M 3T9
Tel: (403) 452-3670
TWX: 610-831-2431

Hewlett-Packard (Canada) Ltd.
210, 7220 Fisher St. S.E.
Calgary T2H 2H8
Tel: (403) 253-2713
TWX: 610-821-6141

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
10691 Shellbridge Way
Richmond V6X 2W7
Tel: (604) 270-2277
TWX: 610-925-5059

MANITOBA
Hewlett-Packard (Canada) Ltd.
380-550 Century St.
St. James,
Winnipeg R3H 0Y1
Tel: (204) 786-6701
TWX: 610-671-3531

NOVA SCOTIA
Hewlett-Packard (Canada) Ltd.
P.O. Box 931
800 Windmill Road
Dartmouth B3B 1L1
Tel: (902) 469-7820
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd.
1020 Morrison Dr.
Ottawa K2H 8K7
Tel: (613) 820-6483
TWX: 610-563-1636

Hewlett-Packard (Canada) Ltd.
6877 Goreway Drive
Mississauga L4V 1M8
Tel: (416) 678-9430
TWX: 610-492-4246

Hewlett-Packard (Canada) Ltd.
552 Newbold Street
London N6E 2S5
Tel: (519) 686-9181
TWX: 610-352-1201

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Blvd
Pointe Claire H9R 1G7
Tel: (514) 697-4232
TWX: 610-422-3022

FOR CANADIAN AREAS NOT LISTED:
Contact Hewlett-Packard (Canada) Ltd. in Mississauga.

CENTRAL, SOUTH AMERICA

ARGENTINA
Hewlett-Packard Argentina S.A.
Santa Fe 2035, Martinez
6140 **Buenos Aires**
Tel: 792-1239, 798-6066
Telex: 122443 AR CIGY
Cable: HEWPACKARG

Biotron S.A.C.I.y M.
Avda. Paseo Colon 221
9 piso
1399 **Buenos Aires**
Tel: 30-4846/1851/8364
34-9356/0460/4551
Telex: (33) 17595 BIO AR
Cable: BIOTRON Argentina

BRAZIL
Hewlett-Packard do Brasil I.e.C. Ltda.
Alameda Rio Negro, 750
Alphaville
06400 **Barueri** SP
Tel: 429-3222
Cable: HEWPACK São Paulo

Hewlett-Packard do Brasil I.e.C. Ltda.
Rua Padre Chagas, 32
90000-**Pôrto Alegre**-RS
Tel: 22-2998, 22-5621
Cable: HEWPACK Pôrto Alegre

Hewlett-Packard do Brasil I.e.C. Ltda.
Av. Epitacio Pessoa, 4664
22471-**Rio de Janeiro**-RJ
Tel: 286-0237
Telex: 021-21905 HPBR-BR
Cable: HEWPACK Rio de Janeiro

CHILE
Jorge Calcagni y Cia. Ltda.
Arturo Burhle 065
Casilla 16475
Correo 9, **Santiago**
Tel: 220222
Telex: JCALCAGNI

COLOMBIA
Instrumentación
Henrik A. Langebaek & Kier S.A.
Carrera 7 No. 48-75
Apartado Aéreo 6287
Bogotá, 1 D.E.
Tel: 269-8877
Telex: 44400
Cable: AARIS Bogotá

Instrumentación
H.A. Langebaek & Kier S.A.
Carrera 63 No. 49-A-31
Apartado 54098
Medellin
Tel: 304475

COSTA RICA
Científica Costarricense S.A.
Avenida 2, Calle 5
San Pedro de Montes de Oca
Apartado 10159
San José
Tel: 24-38-20, 24-08-19
Telex: 2367 GALGUR CR
Cable: GALGUR

ECUADOR
CYEDE Cia. Ltda.
P.O. Box 6423 CCI
Av. Eloy Alfaro 1749
Quito
Tel: 450-975, 243-052
Telex: 2548 CYEDE ED
Cable: CYEDE-Quito

Medical Only
Hospitalar S.A.
Casilla 3590
Robles 625
Quito
Tel: 545-250
Cable: HOSPITALAR-Quito

EL SALVADOR
IPESA
Bulevar de los Heroes 11-48
Edificio Sarah 1148
San Salvador
Tel: 252787

GUATEMALA
IPESA
Avenida Reforma 3-48
Zona 9
Guatemala City
Tel: 316627, 314786, 66471-5, ext. 9
Telex: 4192 Teletro Gu

MEXICO
Hewlett-Packard Mexicana, S.A. de C.V.
Av. Periférico Sur No. 6501
Tepepan, Xochimilco
Mexico 23, D.F.
Tel: 905-676-4600
Telex: 017-74-507

Hewlett-Packard Mexicana, S.A. de C.V.
Ave. Constitución No. 2184
Monterrey, N.L.
Tel: 48-71-32, 48-71-84
Telex: 038-410

PANAMA
Electrónico Balboa, S.A.
Aparatado 4929
Panama 5
Calle Samuel Lewis
Edificio "Alfa," No. 2
Ciudad de Panama
Tel: 64-2700
Telex: 3483103 Curundu, Canal Zone
Cable: ELECTRON Panama

PERU
Compañía Electro Médica S.A.
Los Flamencos 145
San Isidro Casilla 1030
Lima 1
Tel: 41-4325
Telex: Pub. Booth 25424 SISIDRO
Cable: ELMED Lima

SURINAM
Surtel Radio Holland N.V.
Grote Hofstr. 3-5
P.O. Box 155
Paramaribo
Tel: 72118, 77880
Cable: Surtel

TRINIDAD & TOBAGO
CARTEL
Caribbean Telecoms Ltd.
P.O. Box 732
69 Frederick Street
Port-of-Spain
Tel: 62-53068

URUGUAY
Pablo Ferrando S.A.C.el.
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Telex: 702 Public Booth
Para Pablo Ferrando
Cable: RADIUM Montevideo

VENEZUELA
Hewlett-Packard de Venezuela C.A.
P.O. Box 50933
Caracas 105
Los Ruices Norte
3a Transversal
Edificio Segre
Caracas 107
Tel: 239-4133 (20 lines)
Telex: 25146 HEWPACK
Cable: HEWPACK Caracas

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard Intercontinental
3495 Deer Creek Road
Palo Alto, California 94304
Tel: (415) 856-1501
TWX: 910-373-1260
Cable: HEWPACK Palo Alto
Telex: 034-8300, 034-8493

EUROPE, NORTH AFRICA, MIDDLE EAST

AUSTRIA
Hewlett-Packard Ges.m.b.H.
Wehlistrasse 29
P.O. Box 7
A-1205 **Vienna**
Tel: 35-16-21-0
Cable: HEWPACK Vienna
Telex: 13582/135066

Hewlett-Packard Ges.m.b.H.
Wehlistrasse, 29
A-1205 **Wien**
Tel: 35-16-21
Telex: 135066

BAHRAIN
Medical Only
Wael Pharmacy
P.O. Box 648
Bahrain
Tel: 54886, 56123
Telex: 8550 WAEL GJ
Cable: WAELPHARM

Al Hamidiya Trading and Contracting
P.O. Box 20074
Manama
Tel: 259978, 259958
Telex: 8895 KALDIA GJ

BELGIUM
Hewlett-Packard Benelux S.A./N.V.
Avenue du Col-Vert, 1, (Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 660 50 50
Cable: PALOBEN Brussels
Telex: 23-494 paloben bru

CYPRUS
Kypronics
19 Gregorios Xenopoulos Street
P.O. Box 1152
Nicosia
Tel: 45628/29
Cable: Kypronics Pandehis
Telex: 3018

CZECHOSLOVAKIA
Hewlett-Packard
Obchodni zastupitelstvi v CSSR
Pisemny styk
Post. schranka 27
CS 118 01 **Praha** 011
CSSR

Vyvojova a Provozni Zakladna
Vyzkumnych Ustavu v Bechovicich
CSSR-25097 **Bechovice u Prahy**
Tel: 89 93 41
Telex: 12133

Institute of Medical Bionics
Vyskumny Ustav Lekarskej Bioniky
Jedlova 6
CS-88346 **Bratislava-Kramare**
Tel: 44-551
Telex: 93229

DENMARK
Hewlett-Packard A/S
Datavej 52
DK-3460 **Birkerod**
Tel: (02) 81 66 40
Cable: HEWPACK AS
Telex: 37409 hpas dk

Hewlett-Packard A/S
Navervej 1
DK-8600 **Silkeborg**
Tel: (06) 82 71 66
Telex: 37409 hpas dk
Cable: HEWPACK AS

EGYPT
I.E.A.
International Engineering Associates
24 Hussein Hegazi Street
Kasr-el-Aini
Cairo
Tel: 23 829
Telex: 93830
Cable: INTENGASSO

SAMITRO
Sami Amin Trading Office
18 Abdel Aziz Gawish
Abdine-Cairo
Tel: 24932
Cable: SAMITRO CAIRO

FINLAND
Hewlett-Packard Oy
Revontulentie, 7
SF-02100 **Espoo** 10
Tel: (90) 455 0211
Cable: HEWPACKOY
Telex: 121563 hewpa sf

FRANCE
Hewlett-Packard France
Zone d'activites de Courtaboeuf
Avenue des Tropiques
Boite Postale 6
91401 **Orsay**-Cédex
Tel: (1) 907 78 25
TWX: 600048F

Hewlett-Packard France
Chemin des Mouilles
B.P. 162
69130 **Ecully**
Tel: (78) 33 81 25
TWX: 310617F

Hewlett-Packard France
20, Chemin de La Cépière
31081 **Toulouse**
Le Mirail-Cédex
Tel: (61) 40 11 12

Hewlett-Packard France
Le Ligoures
Place Romée de Villeneuve
13100 **Aix-en-Provence**
Tel: (42) 59 41 02
TWX: 410770F

Hewlett-Packard France
2, Allee de la Bourgonette
35100 **Rennes**
Tel: (99) 51 42 44
TWX: 740912F

Hewlett-Packard France
18, rue du Canal de la Marne
67300 **Schiltigheim**
Tel: (88) 83 08 10
TWX: 890141F

Hewlett-Packard France
Immeuble péricentre
rue van Gogh
59650 **Villeneuve** D'Ascq
Tel: (20) 91 41 25
TWX: 160124F

Hewlett-Packard France
Bâtiment Ampère
Rue de la Commune de Paris
B.P. 300
93153 **Le Blanc Mesnil**-Cédex
Tel: (01) 931 88 50
Telex: 211032F

Hewlett-Packard France
Av. du Pdt. Kennedy
33700 **Merignac**
Tel: (56) 97 01 81

Hewlett-Packard France
Immeuble Lorraine
Boulevard de France
91035 **Evry**-Cédex
Tel: 077 96 60
Telex: 692315F

Hewlett-Packard France
23 Rue Lothaire
57000 **Metz**
Tel: (87) 65 53 50

GERMAN FEDERAL REPUBLIC
Hewlett-Packard GmbH
Vertriebszentrale Frankfurt
Berner Strasse 117
Postfach 560 140
D-6000 **Frankfurt** 56
Tel: (06011) 50041
Cable: HEWPACKSA Frankfurt
Telex: 04 13249 hpffm d

Hewlett-Packard GmbH
Technisches Büro Böblingen
Herrenberger Strasse 110
D-7030 **Böblingen,**
Württemberg
Tel: (07031) 667-1
Cable: HEWPACK Böblingen
Telex: 07265739 bbn

Hewlett-Packard GmbH
Technisches Büro Düsseldorf
Emanuel-Leutze-Str. 1 (Seestern)
D-4000 **Düsseldorf**
Tel: (0211) 5971-1
Telex: 085/86 533 hpdd d

Hewlett-Packard GmbH
Technisches Büro Hamburg
Kapstadtring 5
D-2000 **Hamburg** 60
Tel: (040) 63804-1
Cable: HEWPACKSA Hamburg
Telex: 21 63 032 hphh d

Hewlett-Packard GmbH
Technisches Büro Hannover
Am Grossmarkt 6
D-3000 **Hannover** 91
Tel: (0511) 46 60 01
Telex: 092 3259

Hewlett-Packard GmbH
Technisches Büro Nürnberg
Neumeyerstrasse 90
D-8500 **Nürnberg**
Tel: (0911) 52 20 83
Telex: 0623 860

EUROPE, NORTH AFRICA, MIDDLE EAST

Hewlett-Packard GmbH
Technisches Büro München
Eschenstrasse 5
D-8021 **Taufkirchen**
Tel: (089) 6117-1
Telex: 0524985

Hewlett-Packard GmbH
Technisches Büro Berlin
Kaithstrasse 2-4
D-1000 **Berlin** 30
Tel: (030) 24 90 86
Telex: 018 3405 hpbln d

GREECE

Kostas Karayannis
8 Omirou Street
Athens 133
Tel: 32 30 303/32/37 731
Telex: 21 59 62 RKAR GR
Cable: RAKAR ATHENS

ICELAND

Medical Only
Elding Trading Company Inc.
Hafnarvoli - Tryggvagötu
P.O. Box 895
IS-**Reykjavik**
Tel: 1 58 20/1 63 03
Cable: ELDING Reykjavik

IRELAND

Hewlett-Packard Ltd.
King Street Lane
Winnersh, Wokingham
Berkshire, RG11 5AR
GB-England
Tel: (0734) 78 47 74
Telex: 847178
Cable: Hewpie London

Hewlett-Packard Ltd.
Kestrel House
Clanwilliam Place
Lower Mount Street
Dublin 2, Eire

Hewlett-Packard Ltd.
2C Avongberg Ind. Est.
Long Mile Road
Dublin 12
Tel: 514322/514224
Telex: 30439

Medical Only
Cardiac Services (Ireland) Ltd.
Kilmore Road
Artane
Dublin 5, Eire
Tel: (01) 315820

Medical Only
Cardiac Services Co.
95A Finaghy Rd. South
Belfast BT10 0BY
GB-Northern Ireland
Tel: (0232) 625566
Telex: 747626

ISRAEL

Electronics Engineering Div.
of Motorola Israel Ltd.
16, Kremenetski Street
P.O. Box 25016
Tel-Aviv
Tel: 38973
Telex: 33569, 34164
Cable: BASTEL Tel-Aviv

ITALY

Hewlett-Packard Italiana S.p.A.
Via G. Di Vittorio, 9
20063 **Cernusco Sul Naviglio** (MI)
Tel: (2) 903691
Telex: 334632 HEWPACKIT

Hewlett-Packard Italiana S.p.A.
Via Turazza, 14
35100 **Padova**
Tel: (49) 664888
Telex: 430315 HEWPACKI

Hewlett-Packard Italiana S.p.A.
Via G. Armellini 10
I-00143 **Roma**
Tel: (06) 54 69 61
Telex: 610514
Cable: HEWPACKIT Roma

Hewlett-Packard Italiana S.p.A.
Corso Giovanni Lanza 94
I-10133 **Torino**
Tel: (011) 659308
Telex: 221079

Hewlett-Packard Italiana S.p.A.
Via Principe Nicola 43 G/C
I-95126 **Catania**
Tel: (095) 37 05 04
Telex: 970291

Hewlett-Packard Italiana S.p.A.
Via Nuova san Rocco A
Capadimonte, 62A
80131 **Napoli**
Tel: (081) 710698

Hewlett-Packard Italiana S.p.A.
Via Martin Luther King, 38/111
I-40132 **Bologna**
Tel: (051) 402394
Telex: 511630

JORDAN

Mouasher Cousins Co.
P.O. Box 1387
Amman
Tel: 24907/39907
Telex: SABCO JO 1456
Cable: MOUASHERCO

KUWAIT

Al-Khaldiya Trading & Contracting
P.O. Box 830-Safat
Kuwait
Tel: 42 4910/41 1726
Telex: 2481 Areeg kt
Cable: VISCOUNT

LUXEMBURG

Hewlett-Packard Beneluz S.A./N.V.
Avenue du Col-Vert, 1
(Groenkraaglaan)
B-1170 **Brussels**
Tel: (02) 660 5050
Cable: PALOBEN Brussels
Telex: 23 494

MOROCCO

Dolbeau
81 rue Karatchi
Casablanca
Tel: 3041 82
Telex: 23051/22622
Cable: MATERIO

Gerep
2, rue d'Agadir
Boite Postal 156
Casablanca
Tel: 272093/5
Telex: 23 739
Cable: GEREP-CASA

NETHERLANDS

Hewlett-Packard Benelux N.V.
Van Heuven Goedhartlaan 121
P.O. Box 667
1181KK **Amstelveen**
Tel: (20) 47 20 21
Cable: PALOBEN Amsterdam
Telex: 13 216

NORWAY

Hewlett-Packard Norge A/S
Ostendalen 18
P.O. Box 34
1345 **Osteraas**
Tel: (02) 1711 80
Telex: 16621 hpnas n

Hewlett-Packard Norge A/S
Nygaardsgaten 114
P.O. Box 4210
5013 Nygaardsgaten,
Bergen
Tel: (05) 21 97 33

POLAND

Biuro Informacji Technicznej
Hewlett-Packard
Ul Stawki 2, 6P
PL00-950 **Warszawa**
Tel: 39 59 62, 39 51 87
Telex: 81 24 53

PORTUGAL

Telectra-Empresa Técnica de
Equipamentos Eléctricos S.a.r.l.
Rua Rodrigo da Fonseca 103
P.O. Box 2531
P-**Lisbon** 1
Tel: (19) 68 60 72
Cable: TELECTRA Lisbon
Telex: 12598

Medical Only
Mundinter
Intercambio Mundial de Comércio
S.a.r.l.
P.O. Box 2761
Avenida Antonio Augusto
de Aguiar 138
P-**Lisbon**
Tel: (19) 53 21 31/7
Telex: 16691 munter p
Cable: INTERCAMBIO Lisbon

QATAR

Nasser Trading & Contracting
P.O. Box 1563
Doha
Tel: 22170
Telex: 4439 NASSER
Cable: NASSER

ROMANIA

Hewlett-Packard Reprezentanta
Bd.n. Balcescu 16
Bucuresti
Tel: 15 80 23/13 88 65
Telex: 10440

SAUDI ARABIA

Modern Electronic
Establishment (Head Office)
P.O. Box 1228, Baghdadiah Street
Jeddah
Tel: 27 798
Telex: 40035
Cable: ELECTA JEDDAH

Modern Electronic Establishment
(Branch)
P.O. Box 2728
Riyadh
Tel: 62596/66232
Telex: 202049

Modern Electronic Establishment
(Branch)
P.O. Box 193
Al-Khobar
Tel: 44678-44813
Telex: 670136
Cable: ELECTA AL-KHOBAR

SPAIN

Hewlett-Packard Española, S.A.
Calle Jerez 3
E-**Madrid** 16
Tel: (1) 458 26 00 (10 lines)
Telex: 23515 hpe

Hewlett-Packard Española S.A.
Colonia Mirasierra
Edificio Juban
c/o Costa Brava, 13
Madrid 34

Hewlett-Packard Española, S.A.
Milanesado 21-23
E-**Barcelona** 17
Tel: (3) 203 6200 (5 lines)
Telex: 52603 hpbe e

Hewlett-Packard Española, S.A.
Av Ramón y Cajal, 1
Edificio Sevilla, planta 9°
E-**Sevilla** 5
Tel: 64 44 54/58

Hewlett-Packard Española S.A.
Edificio Albia II 7° B
E-**Bilbao** 1
Tel: 23 83 06/23 82 06

Hewlett-Packard Española S.A.
C/Ramon Gordillo 1
(Entlo.)
E-**Valencia** 10
Tel: 96-361.13.54/361.13.58

SWEDEN

Hewlett-Packard Sverige AB
Enighetsvägen 3, Fack
S-161 **Bromma** 20
Tel: (08) 730 05 50
Telex: 10721
Cable: MEASUREMENTS
Stockholm

Hewlett-Packard Sverige AB
Frötallsgatan 30
S-421 32 **Västra Frölunda**
Tel: (031) 49 09 50
Telex: 10721 via Bromma office

SWITZERLAND

Hewlett-Packard (Schweiz) AG
Zürcherstrasse 20
P.O. Box 307
CH-8952 **Schlieren-Zürich**
Tel: (01) 7305240
Telex: 53933 hpag ch
Cable: HPAG CH

Hewlett-Packard (Schweiz) AG
Château Bloc 19
CH-1219 **Le Lignon-Geneva**
Tel: (022) 96 03 22
Telex: 27333 hpag ch
Cable: HEWPACKAG Geneva

SYRIA

General Electronic Inc.
Nuri Basha-Ahnaf Ebn Kays Street
P.O. Box 5781
Damascus
Tel: 33 24 87
Telex: 11215 ITIKAL
Cable: ELECTROBOR DAMASCUS

Medical only
Sawah & Co.
Place Azmé
B.P. 2308
Damascus
Tel: 16 367-19 697-14 268
Telex: 11304 SATACO SY
Cable: SAWAH, DAMASCUS

Suleman Hilal El Mlawi
P.O. Box 2528
Mamoun Bitar Street, 56-58
Damascus
Tel: 11 46 63
Telex: 11270
Cable: HILAL DAMASCUS

TUNISIA

Tunisie Electronique
31 Avenue de la Liberte
Tunis
Tel: 260 144

Corema
1 ter. Av. de Carthage
Tunis
Tel: 253 821
Telex: 12319 CABAM TN

TURKEY

TEKNIM Company Ltd.
Riza Sah Pehlevi
Caddesi No. 7
Kavaklidere, **Ankara**
Tel: 275800
Telex: 42155

Teknim Com., Ltd.
Barbaros Bulvari 55/12
Besiktas, **Istanbul**
Tel: 613 546
Telex: 23540

E.M.A.
Muhendislik Kollektif Sirketi
Mediha Eldem Sokak 41/6
Yüksel Caddesi
Ankara
Tel: 17 56 22
Cable: EMATRADE/Ankara

Yilmaz Ozyurek
Milli Mudafaa Cad 16/6
Kizilay
Ankara
Tel: 25 03 09 - 17 60 26
Telex: 42576 OZEK TR
Cable: OZYUREK ANKARA

UNITED ARAB EMIRATES

Emitac Ltd. (Head Office)
P.O. Box 1641
Sharjah
Tel: 354121/3
Telex: 8136

Emitac Ltd. (Branch Office)
P.O. Box 2711
Abu Dhabi
Tel: 331370/1

UNITED KINGDOM

Hewlett-Packard Ltd.
King Street Lane
Winnersh, Wokingham
Berkshire RG11 5AR
GB-England
Tel: (0734) 784774
Telex: 84 71 78/9

Hewlett-Packard Ltd.
Fourier House,
257-263 High Street
London Colney
St. Albans, Herts
GB-England
Tel: (0727) 24400
Telex: 1-8952716

Hewlett-Packard Ltd.
Trafalgar House
Navigation Road
Altrincham
Cheshire WA14 1NU
GB-England
Tel: (061) 928 6422
Telex: 668068

Hewlett-Packard Ltd.
Lygon Court
Hereward Rise
Dudley Road
Halesowen,
West Midlands, B62 8SD
GB-England
Tel: (021) 501 1221
Telex: 339105

Hewlett-Packard Ltd.
Wedge House
799, London Road
Thornton Heath
Surrey, CR4 6XL
GB-England
Tel: (01) 684-0103/8
Telex: 946825

Hewlett-Packard Ltd.
14 Wesley St
Castleford
Yorks WF10 1AE
Tel: (0977) 550016
TWX: 5557335

Hewlett-Packard Ltd.
Tradax House
St. Mary's Walk
Maidenhead
Berkshire, SL6 1ST
GB-England

Hewlett-Packard Ltd.
Morley Road
Staplehill
Bristol, BS16 4QT
GB-England

Hewlett-Packard Ltd.
South Queensferry
West Lothian, EH30 9TG
GB-Scotland
Tel: (031) 331 1188
Telex: 72682

Hewlett-Packard Ltd.
Kestrel House
Clanwilliam Place
Lower Mount Street
Dublin 2, Eire

Hewlett-Packard Ltd.
2C Avonberg Ind. Est.
Long Mile Road
Dublin 12
Tel: 514322/514224
Telex: 30439

USSR

Hewlett-Packard
Representative Office
USSR
Pokrovsky Boulevard 4/17-kw 12
Moscow 101000
Tel: 294 20 24
Telex: 7825 hewpak su

YUGOSLAVIA

Iskra Commerce, n.sol.o.
Zastopstvo Hewlett-Packard
Obilicev Venac 26
YU 11000 **Beograd**
Tel: 636-955
Telex: 11530

Iskra Commerce, n.sol.o.
Zastopstvo Hewlett-Packard
Miklosiceva 38/VII
YU-61000 **Ljubljana**
Tel: 321-674, 315-879
Telex: 31583

SALES OFFICES
(cont.)

EUROPE, NORTH AFRICA, MIDDLE EAST

SOCIALIST COUNTRIES NOT SHOWN, PLEASE CONTACT:
Hewlett-Packard Ges.m.b.H.
Handelskai 52
P.O. Box 7
A-1205 **Vienna,** Austria
Tel: (0222) 35 16 21 to 27
Cable: HEWPAK Vienna
Telex: 75923 hewpak a

MEDITERRANEAN AND MIDDLE EAST COUNTRIES NOT SHOWN, PLEASE CONTACT:
Hewlett-Packard S.A.
Mediterranean and Middle East Operations
35, Kolokotroni Street
Platia Kefallariou
GR-Kifissia-**Athens,** Greece
Tel: 8080359/429
Telex: 21-6588
Cable: HEWPACKSA Athens

FOR OTHER AREAS NOT LISTED, CONTACT:
Hewlett-Packard S.A.
7, rue du Bois-du-Lan
P.O. Box
CH-1217 Meyrin 2 - **Geneva**
Switzerland
Tel: (022) 82 70 00
Cable: HEWPACKSA Geneva
Telex: 2 24 86

UNITED STATES

ALABAMA
P.O. Box 4207
8290 Whitesburg Dr.
Huntsville 35802
Tel: (205) 881-4592

6933 E. Roebuck Blvd.
Birmingham 35206
Tel: (205) 836-2203/2

ARIZONA
2336 E. Magnolia St.
Phoenix 85034
Tel: (602) 244-1361

2424 East Aragon Rd.
Tucson 85706
Tel: (602) 889-4661

***ARKANSAS**
Medical Service Only
P.O. Box 5646
Brady Station
Little Rock 72215
Tel: (501) 376-1844

CALIFORNIA
1579 W. Shaw Ave.
Fresno 93771
Tel: (209) 224-0582

1430 East Orangethorpe Ave.
Fullerton 92631
Tel: (714) 870-1000

3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2671

5400 West Rosecrans Blvd.
P.O. Box 92105
World Way Postal Center
Los Angeles 90009
Tel: (213) 776-7500
TWX: 910-325-6608

***Los Angeles**
Tel: (213) 776-7500

3200 Hillview Av.
Palo Alto, CA 94304
Tel: (408) 988-7000

3003 Scott Boulevard
Santa Clara 95050
Tel: (408) 988-7000
TWX: 910-338-0518

***Ridgecrest**
Tel: (714) 446-6165

646 W. North Market Blvd.
Sacramento 95834
Tel: (916) 929-7222

9606 Aero Drive
P.O. Box 23333
San Diego 92123
Tel: (714) 279-3200

***Tarzana**
Tel: (213) 705-3344

COLORADO
5600 DTC Parkway
Englewood 80110
Tel: (303) 771-3455

CONNECTICUT
47 Barnes Industrial Road
Barnes Park South
Wallingford 06492
Tel: (203) 265-7801

FLORIDA
P.O. Box 24210
2727 N.W. 62nd Street
Ft. Lauderdale 33309
Tel: (305) 973-2600

4080 Woodcock Drive #132
Brownett Building
Jacksonville 32207
Tel: (904) 398-0663

P.O. Box 13910
6177 Lake Ellenor Dr.
Orlando 32809
Tel: (305) 859-2900

P.O. Box 12826
Suite 5, Bldg. 1
Office Park North
Pensacola 32575
Tel: (904) 476-8422

Computer Systems Only
110 South Hoover Blvd.
Suite 120
Tampa 33609
Tel: (813) 872-0900

GEORGIA
P.O. Box 105005
450 Interstate North Parkway
Atlanta 30348
Tel: (404) 955-1500
TWX: 810-766-4890

Medical Service Only
***Augusta** 30903
Tel: (404) 736-0592

P.O. Box 2103
1172 N. Davis Drive
Warner Robins 31098
Tel: (912) 922-0449

HAWAII
2875 So. King Street
Honolulu 96826
Tel: (808) 955-4455

ILLINOIS
5201 Tollview Dr.
Rolling Meadows 60008
Tel: (312) 255-9800
TWX: 910-687-2260

INDIANA
7301 North Shadeland Ave.
Indianapolis 46250
Tel: (317) 842-1000
TWX: 810-260-1797

IOWA
2415 Heinz Road
Iowa City 52240
Tel: (319) 351-1020

KENTUCKY
10170 Linn Station Road
Suite 525
Louisville 40223
Tel: (502) 426-0100

LOUISIANA
P.O. Box 1449
3229-39 Williams Boulevard
Kenner 70063
Tel: (504) 443-6201

MARYLAND
7121 Standard Drive
Parkway Industrial Center
Hanover 21076
Tel: (301) 796-7700
TWX: 710-862-1943

2 Choke Cherry Road
Rockville 20850
Tel: (301) 948-6370
TWX: 710-828-9684

MASSACHUSETTS
32 Hartwell Ave.
Lexington 02173
Tel: (617) 861-8960
TWX: 710-326-6904

MICHIGAN
23855 Research Drive
Farmington Hills 48024
Tel: (313) 476-6400

724 West Centre Ave.
Kalamazoo 49002
Tel: (616) 323-8362

MINNESOTA
2400 N. Prior Ave.
St. Paul 55113
Tel: (612) 636-0700

MISSISSIPPI
322 N. Mart Plaza
Jackson 39206
Tel: (601) 982-9363

MISSOURI
11131 Colorado Ave.
Kansas City 64137
Tel: (816) 763-8000
TWX: 910-771-2087

1024 Executive Parkway
St. Louis 63141
Tel: (314) 878-0200

NEBRASKA
Medical Only
7101 Mercy Road
Suite 101
Omaha 68106
Tel: (402) 392-0948

NEVADA
***Las Vegas**
Tel: (702) 736-6610

NEW JERSEY
W. 120 Century Rd.
Paramus 07652
Tel: (201) 265-5000
TWX: 710-990-4951

Crystal Brook Professional Building
Route 35
Eatontown 07724
Tel: (201) 542-1384

NEW MEXICO
P.O. Box 11634
Station E
11300 Lomas Blvd., N.E.
Albuquerque 87123
Tel: (505) 292-1330
TWX: 910-989-1185

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2484
TWX: 910-9983-0550

NEW YORK
6 Automation Lane
Computer Park
Albany 12205
Tel: (518) 458-1550
TWX: 710-444-4961

650 Perinton Hill Office Park
Fairport 14450
Tel: (716) 223-9950
TWX: 510-253-0092

No. 1 Pennsylvania Plaza
55th Floor
34th Street & 8th Avenue
New York 10001
Tel: (212) 971-0800

5858 East Molloy Road
Syracuse 13211
Tel: (315) 455-2486

1 Crossways Park West
Woodbury 11797
Tel: (516) 921-0300
TWX: 510-221-2183
Tel: (513) 671-7400

NORTH CAROLINA
5605 Roanne Way
Greensboro 27405
Tel: (919) 852-1800

OHIO
Medical/Computer Only
Bldg. 300
1313 E. Kemper Rd.
Cincinnati 45426
16500 Sprague Road
Cleveland 44130
Tel: (216) 243-7300
TWX: 810-423-9430

330 Progress Rd.
Dayton 45449
Tel: (513) 859-8202

1041 Kingsmill Parkway
Columbus 43229
Tel: (614) 436-1041

OKLAHOMA
P.O. Box 32008
6301 N. Meridan Avenue
Oklahoma City 73112
Tel: (405) 721-0200

9920 E. 42nd Street
Suite 121
Tulsa 74145
Tel: (918) 665-3300

OREGON
17890 S.W. Lower Boones Ferry Road
Tualatin 97062
Tel: (503) 620-3350

PENNSYLVANIA
111 Zeta Drive
Pittsburgh 15238
Tel: (412) 782-0400

1021 8th Avenue
King of Prussia Industrial Park
King of Prussia 19406
Tel: (215) 265-7000
TWX: 510-660-2670

PUERTO RICO
Hewlett-Packard Inter-Americas
Puerto Rico Branch Office
Calle 272,
Edif. 203 Urg. Country Club
Carolina 00924
Tel: (809) 762-7255
Telex: 345 0514

SOUTH CAROLINA
P.O. Box 6442
6941-0 N. Trenholm Road
Columbia 29260
Tel: (803) 782-6493

TENNESSEE
8914 Kingston Pike
Knoxville 37922
Tel: (615) 523-0522

3027 Vanguard Dr.
Director's Plaza
Memphis 38131
Tel: (901) 346-8370

***Nashville**
Medical Service Only
Tel: (615) 244-5448

TEXAS
4171 North Mesa
Suite C110
El Paso 79902
Tel: (915) 533-3555

P.O. Box 1270
201 E. Arapaho Rd.
Richardson 75080
Tel: (214) 231-6101

P.O. Box 42816
10535 Harwin Dr.
Houston 77036
Tel: (713) 776-6400

***Lubbock**
Medical Service Only
Tel: (806) 799-4472

205 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-8241

UTAH
2160 South 3270 West Street
Salt Lake City 84119
Tel: (801) 972-4711

VIRGINIA
P.O. Box 9669
2914 Hungry Springs Road
Richmond 23228
Tel: (804) 285-3431

Computer Systems/Medical Only
Airport Executive Center
Suite 111
5700 Thurston Avenue
Virginia Beach 23455
Tel: (804) 460-2471

WASHINGTON
Bellefield Office Pk.
1203 - 114th Ave. S.E.
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2446

P.O. Box 4010
Spokane 99202
Tel: (509) 535-0864

***WEST VIRGINIA**
Medical/Analytical Only
4604 Mac Corkle Ave., S.E.
Charleston 25304
Tel: (304) 925-0492

WISCONSIN
150 South Sunny Slope Road
Brookfield 53005
Tel: (414) 784-8800

FOR U.S. AREAS NOT LISTED:
Contact the regional office nearest you:
Atlanta, Georgia....North Hollywood, California....Rockville, Maryland....Rolling Meadows, Illinois. Their complete addresses are listed above.

***Service Only**

HEWLETT
PACKARD

03438-90002

Printed in U.S.A.